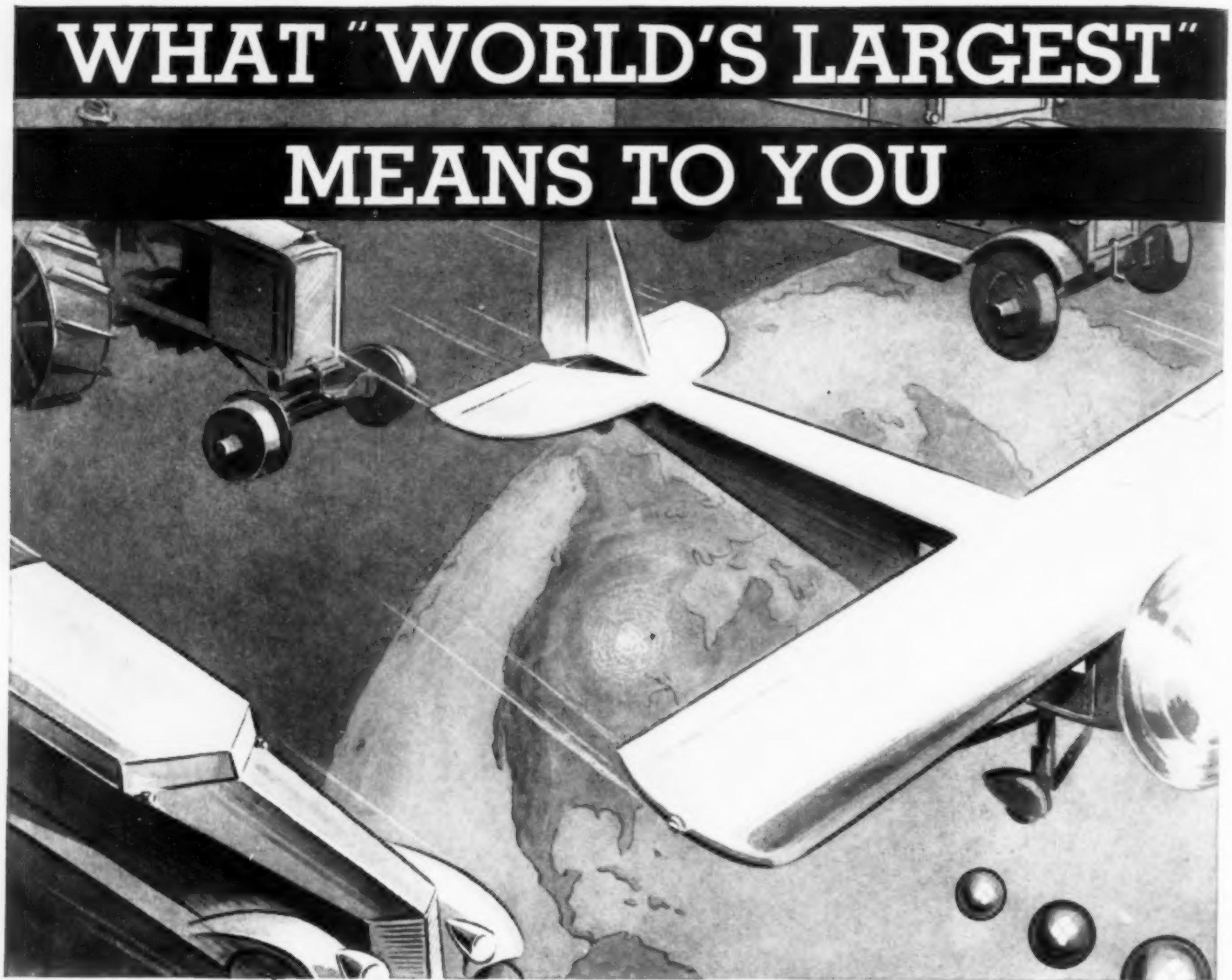

METAL
PROGRESS
D. McDONALD



AS a buyer of alloy steels you are naturally more interested in the quality of a company's product than in the magnitude of its operations. But, reflect for a moment:

— Republic could have achieved its position as the world's largest producer of alloy steels only by successfully meeting the rigid requirements of a larger number of consumers of automotive, roller bearing, ball bearing and other quality steels.

— In building its clientele, Republic must have rendered superior metallurgical service.

Metallurgists who pioneered in the development of alloy steels...men who first offered to the industry the alloy compositions now standardized in the S. A. E. 4100, 4600, 5100 and 6100 series...the facilities of America's largest metallurgical laboratories...modern electric and open hearth furnaces...improved rolling mills — these and many other advantages are at your disposal. Avail yourself of them!

CENTRAL ALLOY DIVISION

REPUBLIC STEEL CORPORATION

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AGATHON STEELS

Metal Progress

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Ernest E. Thum, Editor

APRIL, 1933 VOL. 23, No. 4

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TIMKEN *NICKEL-MOLY*
THE BEARING-TESTED STEEL FOR RING GEARS AND PINIONS

There could be no more convincing evidence of the suitability and superiority of Timken Nickel-Molybdenum Steel for ring gears and pinions than its outstanding performance record in Timken Tapered Roller Bearings.

Here is a steel that has met the severe test of bearing service in a manner unapproached by any other steel.

It is very largely responsible for the supreme load-carrying capacity, wear-resistance and endurance demonstrated by Timken Bearings in industry's toughest bearing jobs.

The qualities that have made Timken Nickel-Moly Steel so supremely successful in bearings are the qualities you need in your ring gears and pinions, namely, uniform chemical properties; uniformly-controlled grain size; high carburizing efficiency; satisfactory response to treatment; and high core ductility.

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THE TIMKEN STEEL AND TUBE COMPANY, CANTON, OHIO

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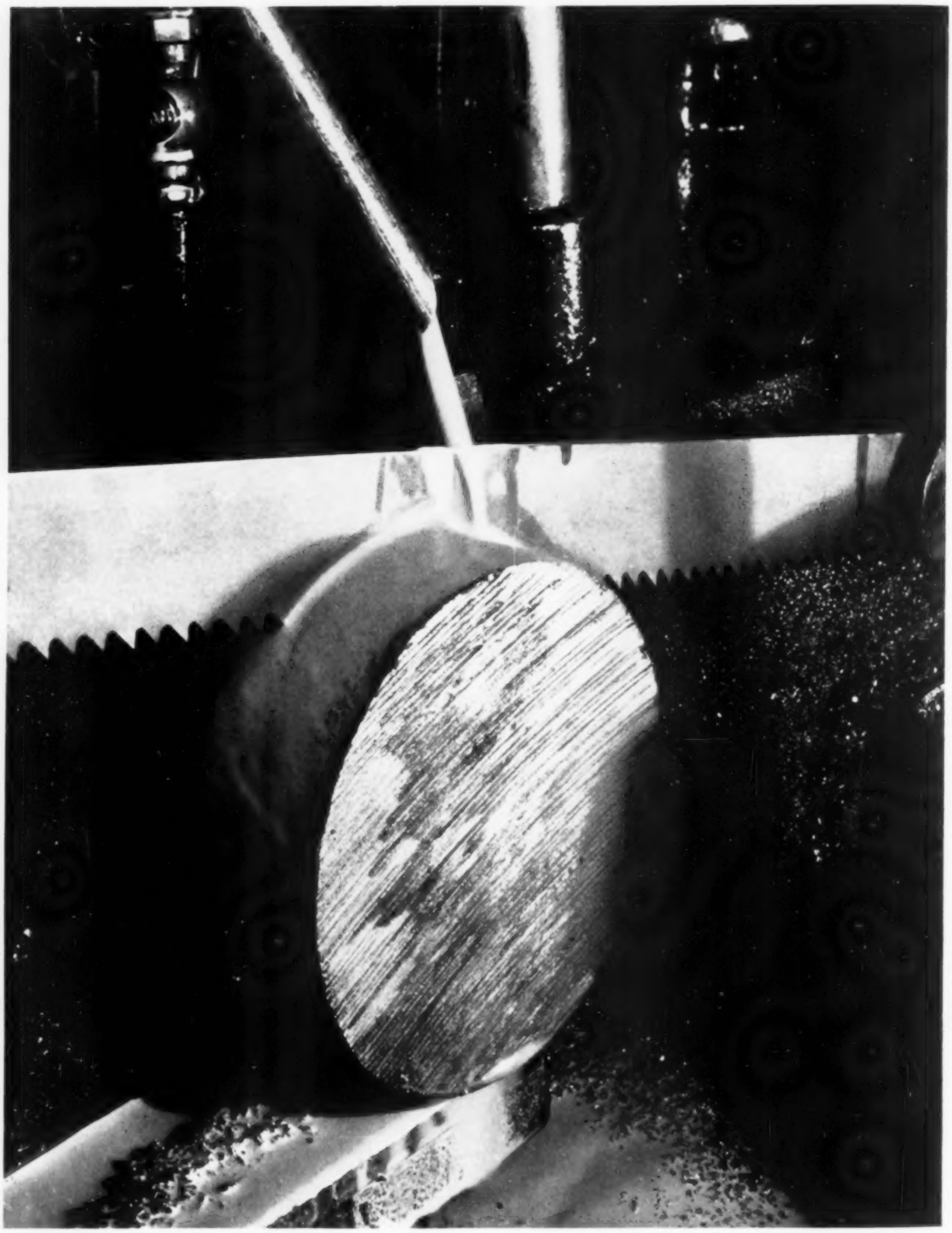
TIMKEN NICKEL MOLY STEELS



Photograph Courtesy of L. S. Starrett Co.

Why Call it a "Hack" Saw?

Factors That Affect Machinability

By F. R. PALMER
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DESPITE THE LARGE AMOUNT OF work done on the problem of machinability of metal (and its companion problem, the efficiency of cutting tools) it is still impossible to discuss the question in precise terms before general audiences. While a trained investigator can draw conclusions based on cutting speeds and feeds, the information readily available in the machine shop is of a much more qualitative nature, and is strongly influenced by personal opinions and by individual conditions in the shop.

Strangely enough, a little trick of the English language has done much to befuddle the subject. One dictionary consulted gives thirteen definitions for the word hard. The first definition is of interest and in this instance we will spell the word in italics: *Hard* means "not easily penetrated; firm; solid; opposed to soft." Of the remaining twelve definitions, seven start with the word difficult. Let us now print it in small capitals: HARD means "difficult."

When we say "That piece of steel is HARD to machine," we mean "difficult to machine." The moment the sentence is out of our mouth, however, we forget we said HARD and start to think *hard* (meaning "not easily penetrated"). If you are disposed to doubt this, just recall that your very next idea usually is "Let's anneal it." The dual meaning of this word has been responsible to a large extent for the fallacy that steels that are difficult to machine are always too *hard* and ought to be annealed softer.

We will therefore avoid the word HARD (meaning difficult) in this discussion. When we mean difficult we will say difficult and when we say *hard* we mean not easy to penetrate (as for example with a Brinell ball or a Rockwell or Vickers brale).

There are at least six separate and distinct factors which may influence the machinability of steel. Each will be briefly described, and theoretically each can be met in two ways—either by changing the machining practice to suit the material, or by changing the material to suit the existing machining practice. Suggestions for applying both corrections will be given as we proceed.

Hardness—Indentation hardness is a relative term. Dead soft annealed high speed steel (Brinell about 220) is much harder than dead soft annealed carbon tool steel (Brinell about 160), which in turn is much harder than annealed mild steel (Brinell about 90), and even this is harder than soft brass (Brinell about 55). A Brinell hardness of 300 is frequently regarded as the top limit for commercial machining.

Increasing the indentation hardness interferes with machining in three ways:

1. It increases abrasion on the cutting edge of the tool.

2. It generates more heat, tending to soften the tool.

3. It increases tool pressures and the power necessary for machining.

Several corrections may be made at the machine to counteract greater Brinell hardness:

1. Reduce the speed.

2. If possible, increase the depth of cut to compensate for lost speed.

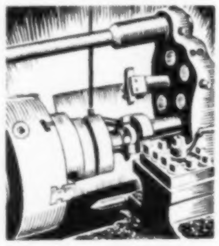
3. Grind the tools with blunter cutting edges—less rake and clearance.

4. Cool the tool with a cutting compound.

Correction in the material:

1. Anneal it to a softer condition, if possible and permissible.

Softness — It is the writer's belief that a steel cannot be too soft for easy machining. True, machining difficulties will frequently attend excessive softness but the trouble is due rather to a toughness which usually accompanies soft metal and causes a gummy machining operation because the chips are reluctant to leave the metal. Cast iron and brass are very soft, compared to steel, yet they machine easily because they are not stringy and tough. Even the softest mild steel will machine freely and easily if it is embrittled by a suitable addition of phosphorus and sulphur.



Toughness is a factor in machinability because it interferes with the separation of the chip from the piece. A tough metal tends to stretch and tear off instead of breaking or crumbling off. Increasing toughness causes one or more of the following: A poor finish on the job, a tendency for burrs to form on delicate corners, greater heat on the extreme edge of the tool, and the presence of long, stringy chips that foul the machine.

Four corrections can ordinarily be made at the machine:

1. Grind the tool sharp — that is, with more clearance and rake — to "pare" the metal off the block.

2. Use chip breakers or lip grooves to break or curl the chips.

3. Use plenty of coolant.

4. Use fine cuts and feeds for finishing.

Possible corrections to be made in the material are listed below with the warning that the last-mentioned corrective is permanent, whereas the others can be changed by subsequent heat treatment.

1. Do not anneal so soft — greater indentation hardness usually decreases the toughness.

2. Procure the material with a cold drawn finish — this increases the hardness but decreases the toughness.

3. Produce a brittle microstructure.

4. Add some embrittling agent to the composition of the metal.

Microstructure, which is still another factor entering into machinability, may be varied by manipulation in manufacturing the steel or its subsequent heat treatment. The term applies to the various forms of pearlite, grain size, cementite network, ferrite banding, normality, and timbre.

There is no agreement among machine shops as to the effects of such structures. For instance, one shop will demand 100% spheroidized pearlite in a high carbon steel, another 100% lamellar pearlite, while a third will want a mixture of both. This does not mean that the machinist does not know what he wants, because he usually does. But it means that a microstructure which is consistently satisfactory to one user will be turned down by another user as responsible for poor machining. The only answer to this is for the steel mills to work out a structure for each individual requirement and then adhere rigidly to it. This is only one of the things which remove "machinability" from the realm of exact science.

One factor merits separate attention — the pro-eutectoid carbides. Certain high alloy steels, rich in carbon, will deposit some of their carbide at the moment the steel freezes in the ingot. This carbide cannot be dissolved or diffused by any method of heat treatment, and continues to exist as so much hard, gritty abrasive embedded throughout the steel. The steel maker, by proper casting, forging and rolling mill practice, is only able to break up these carbides into fine particles, uniformly distributed throughout the bar. High speed steel, high carbon, high chromium tool steel and most stainless steels containing over about 0.70% carbon are good examples.

These hard carbides serve a useful purpose by increasing the wear resistance of the finished part, but in the meantime they definitely interfere with its free machining properties. Their effect on machining is of an abrasive character. Furthermore, they increase the apparent hardness of the metal by acting as "keys" to resist indenting, forming operations, or the removal of chips.

Several corrections may be made at the machine, as listed above under the side-head

Hardness. In addition one should use the hardest and most wear resisting cutting tool that can be had.

Possible corrections in the material are limited by the fact that this carbide cannot be eliminated in any given analysis. Otherwise

1. Careful melting and casting to avoid segregated carbides is helpful.

2. Annealing should usually be to as soft a state as possible — a tedious operation, but well worth while to aid machinability.

Hardening by Cold Work — All metals, when plastically deformed cold, will acquire added hardness and lose a certain degree of toughness. If a steel is not too tough to start with, and does not work harden too rapidly, it may be cold worked to improve its machinability, as noted above under "correctives for toughness." The following paragraphs, however, are designed especially to apply to steels having an austenitic structure. These work harden very rapidly — that is, a small amount of cold work produces a disproportionate increase in hardness. In such steels the machining operation interferes with its own progress.

Cutting Generates Hard Metal

When a cutting tool plows off a chip, it necessarily smears and work hardens the machined surface; the next cut over that surface must remove the metal hardened by cold work. This action is particularly noticeable in milling or drilling where cuts follow each other in rapid succession. It may even be assumed that the metal immediately in front of the tool's cutting edge is compressed and therefore hardened just before it is separated from the piece. Furthermore, the *chips* are greatly hardened and exert a correspondingly greater pressure, and the added friction is responsible for more heat on the nose of the tool.

Corrections to be made at the machine to mitigate this effect are:

1. Decrease the speed materially.

2. Never let the tool — especially a drill — stop feeding and glaze the cut.

3. Use sharp rather than blunt cutting angles on the tools.

As to corrections in the material: Little can be done with an austenitic steel to modify or avoid its work hardening nature. Such steels are almost invariably tough and some of them also have highly frictional characteristics — both of which can be improved by slight modifications in the analysis of the steel.

Frictional Properties — Nothing much was heard of this factor prior to the advent of the high chromium, corrosion resisting steels but it is now recognized as a variable to be distinguished from those already described. The problem involved is exactly the same as trying to let go of a small piece of adhesive tape.

In machining, after the chip has been separated from the piece, it is supposed to slide back over the lip of the tool, clear itself, and get out of the way. Sometimes it does not do it; a portion of the chip adheres to the lip of the tool and refuses to be dislodged. The machinist calls this a bug. After the cutting edge is all stuck up with bugs, it cannot function properly — particularly on delicate cutting — and both the speed and the finish usually suffer.

Of course, *all* steels have some frictional properties in the above sense, but the high chromium stainless steels seem to possess them to an unusual degree. Tooling which will cut freely on almost any other kind of steel will choke up on stainless steel and literally mangle the job.

Corrections at the machine:

1. Other things being equal, bugs form most quickly under high chip pressures and high temperatures — reducing the cutting speed is therefore a big help.

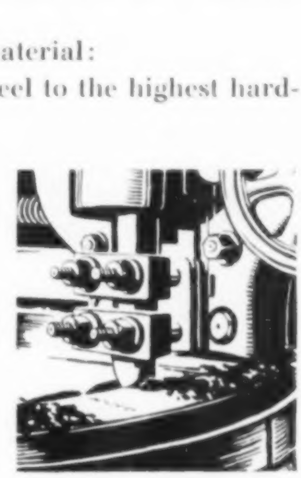
2. Grind tools with a steep top rake, which helps to skid the chips off.

3. Stone out the grinding marks on the cutting edge, as chips slide best on a smooth surface.

Corrections in the material:

1. Heat treat the steel to the highest hardness that can be economically cut.

2. A fundamental correction can be made in the analysis by adding some sulphur or selenium — the latter will completely overcome the difficulty.



Melting High Test Non-Shrinking Pearlitic Iron

By H. H. JUDSON
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Seneca Falls, N. Y.

So many articles have been printed during the past two or three years on the subject of high test iron that another might seem superfluous. However, the methods used in the author's foundry are very different from those hitherto described. Our experiences with this particular iron also are different. It is hoped, therefore, that this paper will present data of interest on these two points, thereby promoting a discussion likely to answer several questions still remaining in the author's mind, principally concerning the fact that our iron has very low (if any) solidification shrinkage.

Six years ago a series of experiments was conducted in the foundry of Goulds Pumps, Inc., to develop an iron that would be suitable for use in the fluid ends of high pressure pumps (especially the ends of oil-line pumps). These fluid ends or cylinders are heavy castings weighing from 2000 to 3000 lb. Wall thickness varies from 1½ to 2½ in., the average being 2¼ in.; internal sections are much heavier. This gives a slow-cooling casting, which, under our old methods, was prone to develop internal shrinks or draws.

The principal purpose of these experiments was to determine what effect the various common elements occurring in cast iron had upon the strength of the castings. The series included heats made up of different burdens, all of which contained steel rails but with various amounts of malleable pig, charcoal pig, low silicon pig, and alloys of nickel and chromium. Cylinders were cast from these heats and then were machined and tested to destruction.

Average bursting pressure was in the neighborhood of 3500 lb. per sq.in. Tensile tests on samples cut from the walls of these cylinders gave a strength of from 30,000 to 35,000 lb. per sq.in. Chemical analyses showed a range of silicon contents from 0.8 to 2.0%, manganese from 0.5 to 1.0%, and total carbon from 3.10 to 3.40%.

These physical tests were not sufficient to meet the needs of the engineering department. However, an analysis of the results of the various tests showed that the one element having the greatest effect on the desired properties was carbon. Both the percentage of total carbon present and the condition in which it existed in the casting were found to be of equal importance. (Results from the alloy heats were not uniform, owing to the lack of knowledge at that time of the proper use of these alloys and the interpretation of the data obtained.)

Carbon the Important Element

The fact that carbon is so important an element, insofar as strength and pressure tightness are concerned, was not a new discovery, but our experimental heats proved conclusively and emphatically that it had, above all other elements, the most profound effect on these properties. The lower the total carbon and graphitic carbon, within certain ranges, the stronger and finer grained was the resulting iron. Hence, the problem resolved itself into one of reducing the total carbon content and controlling it.

In cupola melting, the one simple means of reducing the total carbon of a cast iron

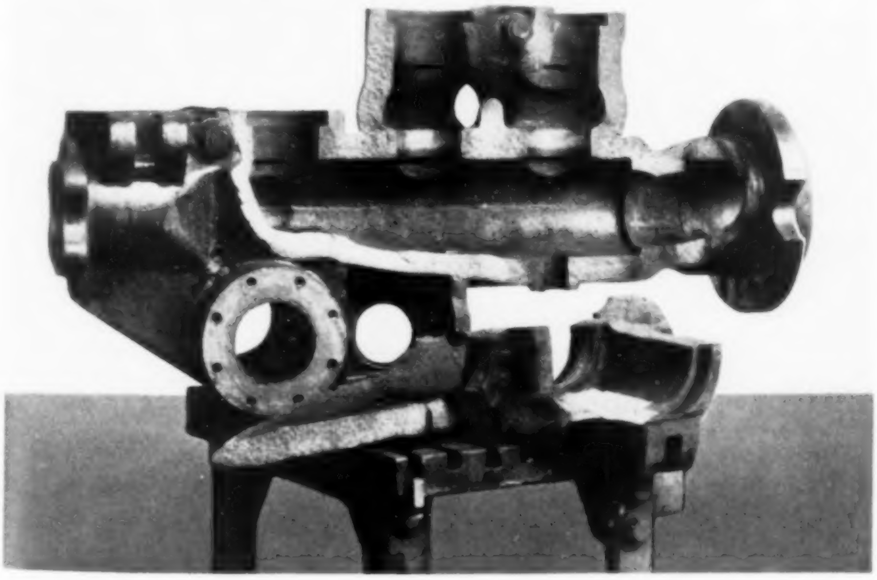
mixture is by adding steel rails to the burden. They had always been used throughout the foundry industry in the regular "semi-steel" mixtures, and their use at Seneca Falls was continued, but in an unusual way. Since it was so desirable to reduce and also to control the carbon content, and since the use of steel rails in the burden was a means to that end, it was decided to melt the rails in a separate cupola to a very hard iron, unsuitable for casting. The softening materials then would be melted in another cupola and the two irons mixed in one ladle. An experimental heat was run according to this method with such excellent results that the idea was developed until it was practicable in production.

Test bars from these early heats were not of much value. The cooling rate of the separately cast test bars was so much faster than that of the cylinders that, although bars and cylinders were of the same chemical composition, the mechanical properties were widely different. To have a more accurate and direct check on each heat an extra cylinder was cast, machined and tested to destruction under hydrostatic pressure. This test was very costly, so a test cylinder was designed of the same wall thickness and general proportions as the pump cylinder but with necessary machining reduced to a minimum. One of these cylinders was cast with each heat and broken under pressure during the remainder of the investigation. The cylinders from an ordinary semi-steel heat, cast during the original investigation, would burst at about 3500 lb. per sq.in. pressure. The same type of cylinder cast with two-cupola iron would develop a bursting pressure of 6000 lb. per sq.in. Wall thickness of this cylinder, shown in the half-tone, is $2\frac{1}{4}$ in.

The melting method finally evolved and now in operation is as follows: The steel rails, with some spiegeleisen and high silicon pig, are melted in a cupola lined to 51 in. diameter. One row of tuyeres, set 7 to 8 in. above the sand bottom, is used. The tap is continuous through a spout of the skimming type. The coke bed extends 34 in. above the top of the tuyeres.

Blast is supplied by a motor-driven, positive displacement blower. It is measured by a volumetric recorder of the orifice-plate type, and runs between 5400 and 5600 cu.ft. per min. Pressure starts at 14 oz. and drops gradually to 6 or 8 oz. at the end of the heat. Blast volume is held between the stated limits throughout the heat by manual control of the blower motor.

At the beginning the coke bed is burned through very completely—a rule adhered to religiously. Then the steel rails, with the spiegeleisen and high silicon pig, are charged carefully by hand. Each charge is kept as level as possible. The cupola then stands fully charged for an hour and a quarter with the tuyere covers opened wide so as to provide a strong natural draft to preheat the entire shaft. The blast is then started and the time noted when iron drips past the tuyeres, which usually is 5 to 6 min. Tap-out comes 6 min. after these drops are



Test Cylinder With $2\frac{1}{4}$-In. Walls, Cast With Each Heat During an Investigation to Develop an Iron Foundry Practice Suitable for Pressure Castings

first seen, and an optical pyrometer indicates an apparent temperature of 2550° F. (no correction for emissivity). All the metal is tapped into one ladle.

In the meantime, the cupola for melting the soft iron has been in blast. A ladle suspended from a crane scale is placed under the spout and a predetermined weight of soft iron is run into it, and it is then poured into the ladle of hard iron from the 54-in. cupola. When sufficient iron has been caught to make the desired mixture, the molds are poured.

For a specific example, the analyses of hard-iron samples taken from the spout at 5-min. intervals during a short heat are given in the table in the next column. All this iron was tapped into one ladle, this fact offsetting the wide variation in analyses, and 7500 lb. of it were mixed with 2000 lb. of soft iron having the following analysis: Silicon 2.40%, sulphur 0.085%, manganese 0.55%, phosphorus 0.45%, total carbon 3.50%. Analysis of the resultant mixture poured into a line-pump cylinder (from which the sample was taken) was as follows: Silicon 1.70%, sulphur 0.105%, manganese 1.09%, phosphorus 0.152%, total carbon 2.74%, graphitic carbon 1.99%, combined carbon 0.75%.

Samples were taken through the $2\frac{1}{4}$-in. wall of the cylinder, this cylinder having $5\frac{3}{4}$-in. bore and weighing 2300 lb. It will be readily seen that a casting of this size would cool very slowly, yet the excellent properties obtained are:

Tensile strength	46,500 lb. per sq.in.
Shear strength	51,500 lb. per sq.in.
Brinell hardness	212
Bursting pressure	6,000 lb. per sq.in.

Transverse tests made on standard $1\frac{1}{4}$-in. round arbitration bars, supported on 12-in. centers, gave 5000 lb. transverse strength and 0.09 in. deflection.

Mixtures and properties given above are for one specific job, and they vary somewhat depending upon the requirements for the finished castings. Charges into the hard iron cupola fall within the following limits: Rails, 1300 to 1500 lb., 15% silicon pig 120 to 140 lb., 20% spiegeleisen 65 to 80 lb., coke splits, 180 lb. The soft iron is also controlled within the following limits: Silicon 2.40 to 2.70%, manganese 0.50 to 0.70%, sulphur 0.085% max., phosphorus 0.45% max., total carbon 3.40 to 3.60%.

Five-ton ladles are then made up with 7000 to 8000 lb. of the hard iron, and 1800 to 2300 lb. of the soft. Castings fall within the following analysis limits: Silicon 1.40 to 1.80%, sulphur 0.10 to 0.11%, manganese 0.85 to 1.10%, phosphorus 0.150 max., and total carbon 2.40 to 2.80%.

Photomicrographs such as those shown on page 23, prove that the iron is distinctly of pearlitic structure, with no free ferrite and only occasionally some free cementite. The graphite exists in short flakes and is nicely broken up. A fracture of a heavy piece shows a remarkably uniform grain structure throughout.

Uniformly Satisfactory Service

This iron has fulfilled all of our requirements. Over 1000 cylinders of various kinds cast from this metal are in service, operating at pressures of from 150 to 1500 lb. per sq.in. It is over five years since the first one was placed in service, and as yet we have had no breakage reported from the field. Each cylinder is checked (before it goes to the machine shop) for chemical analysis, shear strength, and graphite distribution, all of which are determined from a sample cut from the wall of the casting itself. These three checks enable us to discard instantly any cylinder which may be off owing to poor foundry practice.

Behind this method of producing high test iron is the idea that melting the steel in one cupola and tapping all of it into one ladle enables us to gage the carbon content of our final mixture. There is nothing in the steel burden to throw us off, because the raw materials never change, nor does the cupola operation. Soft iron analysis is held uniformly close to specifications from day to day. More important still, the quantity is weighed accurately. Thus, its

Samples From a Cupola Melting Steel Rails

Time of Sample	Silicon	Sulphur	Manganese	Phosphorus	Total Carbon
5 min.	1.07	0.128	0.53	0.080	2.62
10 min.	2.06	0.090	1.44	0.078	2.50
15 min.	2.22	0.082	1.78	0.042	2.40
20 min.	0.91	0.096	0.85	0.067	2.70
25 min.	0.33	0.085	0.97	0.082	2.73

Mixture of Hard Iron and Gray Iron Has Graphite Flakes Well Broken up in Pearlitic Metal. Magnifications 50 and 500 diameters

effect on the final analysis is known beforehand.

The coke bed in the hard iron cupola may seem low to an experienced melter. It was adopted after a series of experimental heats had been run to determine the effect of bed height on the iron. Results showed that with uniform blast, coke splits and charges, the carbon content increased with increase in bed height. Carbon content also increased with increases in coke splits, providing the blast, bed, and charges were held uniform. A 34-in. bed is low enough to prevent too great a carbon pick-up; coupled with a 1¼-hr. soaking period and proper blast volume, it is high enough to bring the iron down white hot from the start. The amount of coke through which the molten iron drops is held to a minimum by setting the tuyeres as close to the sand bottom as possible. This, too, helps to prevent carbon absorption.

The continuous tap also conduces to uniform iron. Iron is withdrawn as fast as it melts, so that it does not lie in contact with the incandescent coke in the well of the cupola. Blast volume is held constant so that a uniform melting condition exists; a high blast makes for a lower carbon content, but this gain is more than offset by excessive loss in silicon and manganese.

At the start of this development, the blast volume was determined by the speed of the blower; we had no means of measuring it exactly nor of holding it uniform throughout a heat. As the heat progressed the pressure drop through the cupola would gradually decrease and the blower would pick up speed, thus causing a gradual increase in the blast from approximately 5200 cu.ft. per min. at the start to 5800 or 5900 cu.ft. at the end. Carbon content decreased slowly through the heat.

Castings poured from these early heats would show spongy spots under the risers. These defects resembled a combination shrink and gas cavity. Larger and higher risers were used, but still the spongy spots occurred. The molds were made in dry sand and the cores were open and well vented, so that the defects were chargeable directly to the iron.

Installation of the blast-volume recorder brought with it a sure means of measuring and controlling the blast. As soon as the meter indicates an increase in blast volume, the motor is slowed down to the speed that will bring the volume back where it belongs. Since inaugurating this practice there has not been the first sign of a defect under a riser.

Spongy spots, we believe, were caused by the presence of gas in the iron which was released when the iron set and gathered at the last place to freeze, directly under the riser. Presence of gas in the iron appeared to be caused by a non-uniform melting condition, when, toward the end of the heat, the increased blast volume brought about an oxidizing condition, or at least a condition that would introduce gas into the metal. One might argue that an increase in blast would tend to raise the melting zone; actually it burns coke in charges *above* the melting zone so that the actual height of the bed was decreased instead of raised. Thus, the melting took place too close to the tuyeres.

Control of the blast volume has done away with this condition. There are no gas pockets anywhere in the castings now.

In the early development we had some trouble in getting iron hot enough and fluid enough to pour; at times iron would freeze on the lip of the crane ladle while pouring. Iron of this same analysis, melted with the blast held uniform, is now sufficiently hot and fluid to meet all our needs.

The above experiences are mentioned because many foundrymen object to a low carbon iron, saying that it sets too quickly and shrinks excessively. Our experience was quite similar until the melting conditions were corrected.

All new designs of cylinders are now molded with flow-off risers only, not large enough to feed. Regardless of the sections of the castings, varying from $1\frac{1}{2}$ in. up to 4 in., no feeding risers are used. Castings have been broken up into small pieces and have shown no signs of internal shrinkage, open-grained metal, nor gas pockets. One particular job weighing 2500 lb. has a circular pipe section $1\frac{1}{2}$ in. thick abutting on a section varying from 3 in. to $4\frac{1}{2}$ in. thick and forming a sharp re-entrant angle, a condition that promotes shrinkage, as everyone knows. No risers are used in pouring even this casting, yet they are entirely sound and solid and are tested at 3500 lb. per sq.in. pressure and do not sweat. They operate under 900 lb. per sq.in. oil pressure, and even then show no signs of sweating.

This same kind of iron is poured into small green sand jobs, such as pump plungers, glands and levers. Standard gates are used. The iron is very hot, so that we experience no difficulty in making the castings run. No risers are used.

Solidification Shrinkage

The iron seems to have almost as long a molten life as our other grades, although such was not the case before we hit upon the proper blast condition. Before, we had difficulty at times in pouring a 5-ton ladle of iron into three molds without iron freezing on the lip; now, we can hold the metal for 15 min. before pouring and encounter no difficulty with dull metal. This is offered as proof that a cast iron low in carbon does not necessarily have a short molten life. (We do not make it a practice to hold the metal in the ladle, because a finer grained structure is obtained by pouring hot.)

One question in connection with this melting practice we would like to have answered: "What is there about this iron that makes it 'non-shrinking,' insofar as the shrinkage troubles of the foundry are concerned?" Low carbon cast irons are supposed to shrink excessively, a thought that we, like many others, had entertained. However, this particular iron does not act in that way. We have no explanation to offer as to why it does not. We have entertained the thought that it might be an iron of an eutectic nature, because it has a very narrow freezing range, a range so narrow that the volume decrease between the liquid and the solid state does not occur in one spot (as a shrinkhole), but owing to lack of time is disseminated throughout the entire casting. Discussion of this viewpoint would be most enlightening to us.

Hints on Forging the Stainless Steels

By R. W. THOMPSON
Chief Metallurgist
Transue & Williams Steel Forging Corp.
Alliance, Ohio

Eccentric Shaft for Gasoline Pump

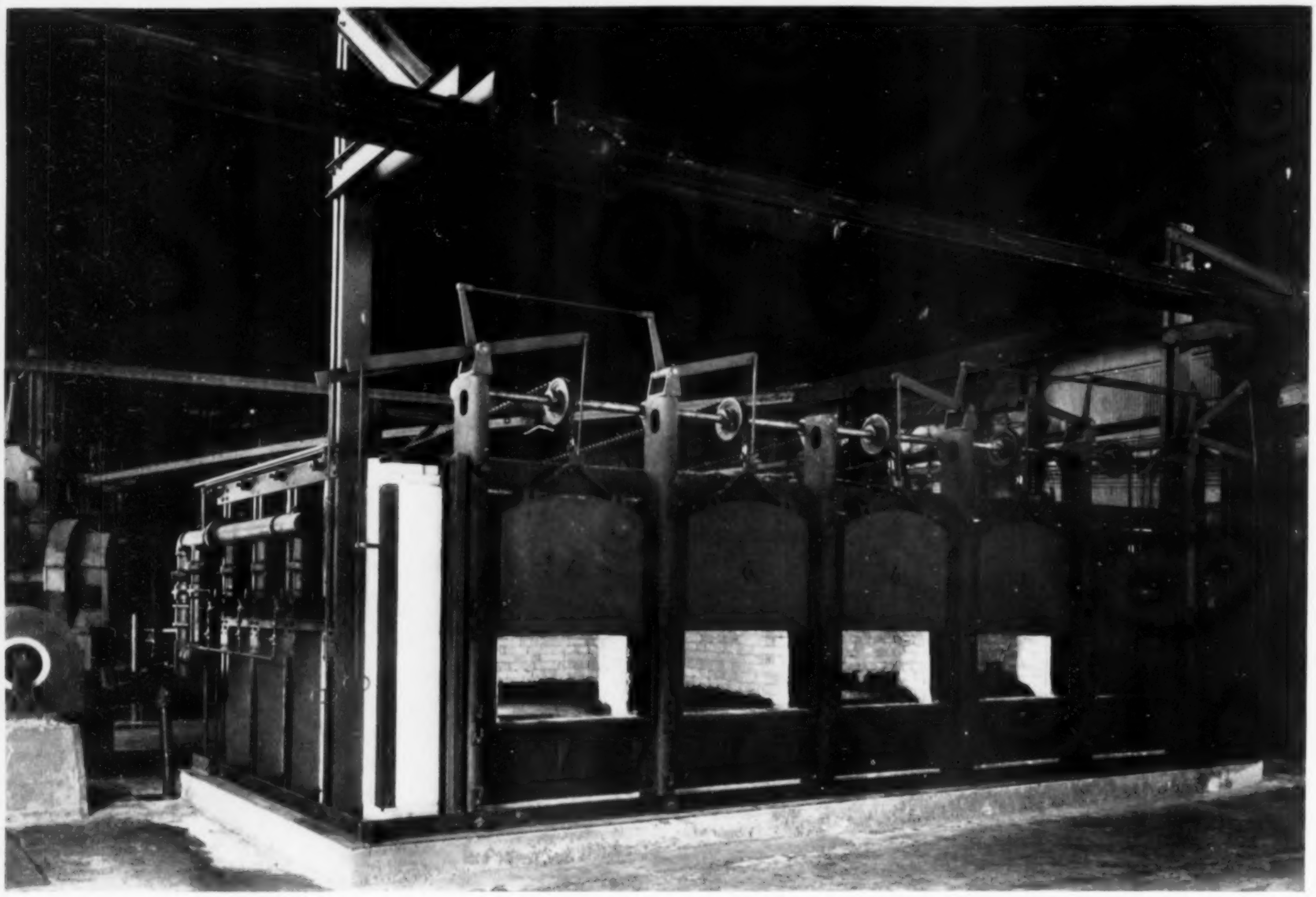
THE HIGH COST OF CORROSION and heat resisting alloys makes it expedient for the manufacturer to watch very carefully all operations during the fabrication of articles from these metals. The design of dies and tools must receive the utmost consideration in order that spoilage during fabrication will be at a minimum and that flash and waste will not be excessive.

Forging of Large Masses — Probably the purchaser of stainless bar stock will never be called upon to make what might be called large forgings. He will probably rely upon some outside organization which possesses the specialized equipment and staff. But at any rate, it is not out of place to emphasize that the slow and thorough preheating of large billets is equally as important as it is for moderate sized forgings. Definite recommendations will be made below.

Selection of Raw Materials — Generally speaking, all the well-known grades of stainless steel and iron are readily forgeable. The 18-8 and the chromium-nickel-silicon-iron types, while presenting slighty greater difficulties than the straight chromium types, are readily forged even into the most difficult shapes, providing the temperature of the metal is carefully watched, and the blank is reheated at the necessary intervals.

Purchase specifications covering the quality of the bar stock should be carefully checked by the metallurgist, and the material adequately inspected before fabrication is allowed to proceed. Of course, it is to be understood that the type and grade of steel is to be determined by the use and service expected for the particular application. These considerations are: (1) Corrosion resistance, either wet or dry, (2) physical properties, including strength at elevated temperatures, and (3) wear resistance or hardenability of the metal. These matters cannot be discussed at length, but are mentioned as being of prime importance in the art of satisfying the ultimate consumer.

Chemical analysis of the bar stock "as received" gives a check of the relationship of the chemical elements in the steel and determines the heat treatment and the susceptibility to hardening. Bars should then be carefully examined for surface defects. Deep roll marks and seams in stainless steels



Large Forging Furnace, 7.5 Ft. Deep, Serves 8000-Lb. Hammer. Two-door preheat at left is 7 ft. 10 in. wide, and three-door production chamber at the right is 16 ft. 10 in. wide

present a more serious problem to the forger than they do in carbon and the ordinary alloy steels. This is due to the resistance to flow and to the poor welding action during forging.

Disks cut from the ends of several bars should be deeply etched in concentrated hydrochloric acid and water (equal parts) at 160° F. (which corrodes them readily) to insure the soundness of the material.

Heating operations preparatory to forging are of utmost importance and every consideration should be given this phase of operation. As these steels are very susceptible to grain growth when heated or soaked at high temperatures, they urgently demand a properly controlled heating furnace. These furnaces should be of the semi-muffled type, to protect the thermocouple and the work from the direct sweep of the flame, thereby making it possible for the actual furnace temperature to be in close relationship with the temperature of the forging bars. Such a furnace, built of ample size to handle the necessary production, will give ideal service for stainless steel heating if fired with the proper mixture of air and fuel and maintained in cleanly condition.

Small bars, 1 in. round or under, if heated carefully and not too rapidly, may be heated to forging temperatures without the necessity of preheating. All bars of greater cross-section should be preheated thoroughly in a furnace with controlled temperature, located adjacent to the high temperature forging furnace. The length of time in the preheating furnace is about twice that necessary to heat any of the ordinary carbon steels of equal cross-section. The forging furnace should also be automatically controlled; in it the preheated bars may be rapidly brought up to the proper forging temperature.

The straight chromium types of corrosion resisting alloys should be forged from temperatures between 2000° F. and 2200° F. This range may be slightly modified for steels in the high carbon ranges, the temperature being reduced with the increase of carbon. The 18-8 types require a slightly higher temperature for forging, usually beginning at 2100° F. to 2200° F., while the reverse of this analysis, or the 17 to 22% nickel and 7 to 10% chromium steels, will not withstand a forging temperature much over 2100° F. Preheating temperature for these alloys should be 1500° F. to 1600° F.; allow plenty

of time to soak the bars or billets throughout.

The drop forger, with a little care, will have no difficulty in preventing injury to the stainless alloys from too cold a working temperature. In most cases effective deformation is practically impossible at temperatures far above the point of injury to the metal. Also, the forging will usually stick in the die impression. The limit of effective deformation may be considered at 1750° F. for the straight chromium types and at 1850° F. for the chromium-nickel types. An exception to this may be cited in the forging practice on 16 to 20% chromium stainless irons which should be worked to about 1400° F. to develop proper grain refinement.

Hammers — Low carbon, high chromium alloys require about 25% more blows under a hammer in forging than is necessary for ordinary steels. This general statement is only a rough guide for the type mentioned, for the stiffness at forging temperature increases rapidly with the carbon and nickel. Cutlery grades, for instance, work like a high speed tool steel. Some of the complex alloys, intended for high temperature service, are also inherently stiff at forging heats.

It is considered more economical to give the required additional blows than to employ a larger size hammer, which would increase the overhead charges and reduce the service life of the die blocks. On account of the additional hammer blows and the resistance of these metals to deformation, several reheatings are sometimes necessary to make a given part. To prolong the forging operations the required amount, the semi-finished forging is placed in the high temperature furnace and again rapidly brought back to forging heat.

Steam hammers are generally best suited for forging stainless because of their ability to strike either a light or heavy blow at will and their more rapid action. For some classes of forgings the board drop hammer is as satisfactory as the steam hammer, especially for small forgings where there is little work to be done in the edger or drawing tool. Also there are many forging designs which may be adapted for board hammer work by putting additional steps in the die for breaking down, or by including an extra semi-finishing impression.

As remarked at the outset, care in designing the die and using hammers in good condition will repay for itself many times in reducing the amount of normal scrap (flash and tongholds) and of abnormal scrap (wasters and defectives). Machining allowances, size tolerances, and necessary draft do not vary in forgings of the same size and design from those necessary in carbon steels.

In upsetting or in header operations most forgings require as many passes as can be tooled in the upsetting machine. These extra steps in forming will avoid the troubles often occasioned by stressing the metal too much and tend to keep scrap losses at a minimum. It is usually found necessary to use a size larger machine on the high chromium-nickel alloys than that used on ordinary forging steels.

Forging defects are more prevalent in the forging of stainless steels than in ordinary steels because of the critical temperatures that must be maintained and the comparatively narrow range in forging. Even a slight overheating

Instruments and Charts for Automatic Control of Preheating and High Heat Chambers Are Behind Glass Windows so Hammer Men Can Be Sure the Heat Is Right

Valve Gate and Seat Are Typical Forgings

will cause a split or rupture in the metal, while too cold a working temperature will cause cold shuts and checks. Oftentimes considerable trouble can be eliminated by striking the first few blows of the hammer lightly and not attempting too severe a reduction at first.

Die Steels — The grade or type of forging die and trimming die steels used should be considered from the standpoint of design of the forging and the production requirements, figuring that the die life when forging stainless will be approximately 75% of that obtained when forging ordinary steels. In other words, if it is considered necessary to use an exceptionally high grade die steel for a given order, due to forging design or for a long run in production, it may be considered even more necessary when making the part in one of the stainless alloys.

Trimming — When it is at all possible, forgings of heat resisting alloys should be hot trimmed and restruck at the hammer. The temperature at which this operation is conducted is very important in order to avoid tearing or breaking which often occurs if the part is trimmed too cold. When cold trimming is necessary for some compelling reason, it is usually necessary to anneal the parts beforehand, because the unavoidable variations in finishing temperatures and cooling rates produce pieces of varying hardness and make it more or less difficult to trim the cold alloys, even those that do not air-harden.

Cooling — Forgings made from these alloys, if finished at a uniform and proper temperature, will have a good surface appearance; and, if allowed to cool in a clean container free of oil or grease, will produce a very presentable product. Any oil or grease on the hot forgings will cause a fusing or baking of these substances on the forgings, and cause difficulties in preparing a clean pickled product.

Barring abuse, the rate of cooling after forging does not need to be carefully watched in the ferritic chromium-iron alloys and the truly austenitic alloys (iron-chromium-nickel and more complex types), for there is no phase change in the structure. On the other hand, the martensitic alloys — that is, those which air harden or oil harden — may at times crack during the cooling. This is due to the differential expansion which occurs in the solid metal (none too plastic) at the transformation ranges. The risk increases with the complexity of the part, variations in cross-sections and contours and surface roughness. Troubles may be avoided by a slow cooling through the transformation of austenite to pearlite (1400° F. to 1100° F.) or through the change from austenite to martensite (700° F. down to 400° F.). It may even be necessary to place the trimmed and restruck forgings directly into a furnace held in the lower region of these ranges and soak them long enough for the structure to change.

Inspection — The proper pickling will readily uncover all surface defects and allow a most thorough inspection.

Heat Treatment of Cobalt High Speed Steel

A TENTATIVE RECOMMENDED PRACtice for the heat treatment of cobalt high speed steels was adopted recently by a subcommittee of the Recommended Practice Committee, A.S.S.T., and is given substantially in full below. It will retain the tentative status for at least one year during which time criticisms are solicited. It is not intended for a specification.

Composition of the steels, as given in the table, covers practically the entire range of cobalt high speed steels now in use; others may require different heat treatment.

Application — Cobalt high speed steels are particularly adapted for cutting hard, gritty, or scaly material, such as cast iron, heat treated steels, or sand castings. They do not show the same increased efficiency in the cutting of soft materials as when cutting comparatively hard metal.

Forging — Heat slowly and uniformly to about 2100° F. Do not forge these steels after they have cooled below 1650° F., as cracking may result. After forging, the steel should not be allowed to cool in air but should be buried immediately in some heat insulating material so as to cool slowly; otherwise forging strains may cause cracks in cooling. These steels must be annealed after forging.

Annealing — Pack in a suitable container with mica dust or sand to which has been added approximately 1% of charcoal by weight. Heat to a temperature of from 1600 to 1700° F. and hold until the heat has thoroughly penetrated the mass. Furnace cool as slowly as possible.

Hardening

Preheating — Heat slowly and uniformly to a temperature of 1450 to 1500° F. Hold at this temperature until the steel is thoroughly heated through and transfer to the high temperature furnace. These steels decarburize readily if held too long at or above the preheating temperature.

Where large tools are to be hardened, a double preheat is often desirable. The first preheating temperature is 1150 to 1300 and the second preheating temperature is 1500 to 1600° F.

High Heat — After transferring to the high temperature furnace, steel No. 1 should be heated quickly to the hardening temperature of 2325 to 2375° F., while types No. 2, 3 and 4 should be heated to a hardening temperature of from 2375 to 2425° F. As soon as the steel has reached this temperature it should be immediately quenched. Prolonged soaking will cause excessive decarburization and some grain growth.

Approximate Composition of Cobalt High Speed Steels

	Carbon	Chromium	Tungsten	Cobalt	Molybdenum	Vanadium
No. 1	0.65 to 0.80	3.5 to 4.5	12.5 to 14.5	3.5 to 5.0	0.40 to 0.50	1.5 to 2.0
No. 2	0.65 to 0.80	3.5 to 4.5	17.5 to 18.5	3.5 to 5.0	0.40 to 0.50	0.75 to 1.5
No. 3	0.65 to 0.85	3.5 to 4.5	17.5 to 18.5	6.0 to 9.0	0.40 to 0.80	1.0 to 2.0
No. 4	0.65 to 0.85	3.5 to 4.5	17.5 to 21.0	10.0 to 13.0	0.40 to 0.80	0.75 to 1.5

Quenching — These steels may be quenched in either still air, air blast or oil, depending upon the size and design *(Continued on p. 62)*

Photograph by Llewellyn Thomas

Ladles

Editorial

Stronger Cast Iron

IRON founders are deserving of much credit for the continuous improvement of their melting and molding practices, which has enabled them to satisfy the demands of their more exacting customers. Even without making any great expenditures for new plant or equipment, the more progressive concerns can now work regularly to specifications thought impossible to achieve some years back.

Much of the improvement has been due to urging from the automotive industry. Cylinder blocks, for instance, must be made of a fluid iron with thin walls, yet must be strong, wear resistant and machinable. This difficult combination has been achieved by extra hot metal, a mixture of pig iron and steel, usually with alloying elements like nickel, chromium, and molybdenum.

Powerful motors, faster acceleration, automatic gear shifting, free-wheeling — all have increased the punishment absorbed by many automotive parts. Not the least of these are the pressure plate castings in clutches. Gray iron, used in the past, is being replaced with alloy iron, almost twice as strong.

Cast iron brake drums have also given great satisfaction; centrifugal casting inside a steel shell being just now a very popular method. High strength gray or alloy iron permits smaller brakes for the smaller wheels decreed by style, wide enough to take the extra punishment of high speed operation. Radiation of heat during severe braking is a problem successfully met by one scheme or another in nearly all designs, but has yet to be solved for high speed bus service on mountain roads.

Heat treated irons are also past the experimental stage as far as camshafts are concerned. The properties achieved by a clever combination of chill molds, alloying, and heat treatment are almost infinite in variety, and the field of usefulness of heat treated iron will therefore be restricted principally by the conservatism of the customers or inadequate promotion by the foundries.

In some respects manufacturers of agricultural equipment are going their automotive brothers one better. Even though machining allowances on castings for the latter have been reduced as low as 3/32 in., the farm implement man believes in casting to much closer limits and no machining at all. Hence one finds innumerable bevel gears, ratchets, and other parts up to 2 in. diameter cast in dry cores to 0.005 in. tolerance, and used as cast.

Farm tools generally use but little high strength or alloy iron. Before a better machine can be built for less money, it is generally necessary to redesign the entire implement, using the capabitities of the new materials to the limit. This requires first that the designers know more about metallurgy than nine out of ten of them do. Substitution of materials for single parts is usually made on the simpler basis of price; for instance, malleable iron has suffered much because in many cases pressed steel parts or welded structures can be substituted at lower cost with no sacrifice in strength.

The higher strength gray irons also challenge malleable castings for certain classes of service, where ductility is not a factor. This challenge will certainly be met by an industry long active in the promotion of sounder, stronger and more reliable metal.

The future therefore holds out interesting developments to the iron founder who can keep abreast of these changing conditions, and who has a staff intelligent enough to embrace the opportunities which can be created.

Unconquered Worlds Ahead

SINCE the science of metallography is so very young, it is only natural that its technique is changing quite rapidly. Most apparent is the increase in precision. By this is meant more than the matter-of-course improvement in sensitivity and accuracy of the furnaces, pyrometers, microscopes and testers. It applies to the study of metals and alloys of highest purity.

Wholly new properties, differing in kind as well as degree, have been found in common metals like zinc, aluminum, and manganese, doubly refined to spectroscopic purity. Hence there is ground for the statement that we do not yet know what iron really is, and possibly Dr. Yensen's guess is true that pure iron — *pure* iron — has no allotropic transformations! That such refinings have more than academic importance is proven by the recent commercial development of oxygen-free copper, 99.99% copper of improved ductility and endurance, to compete with standard electrolytic copper (99.94% copper, long a standard of excellence). The necessity of chasing out the last traces of impurities from zinc is also well known to die-casters.

"Increase of precision" is a phrase which also applies to the unit under observation. Happily the crude micrographs at low power which adorn the literature of 15 years ago have been supplanted by excellent photographs of clearly resolved detail at 500 to 2000 or 3000 magnifications.

Furthermore, precise microscopic work is more than a research tool — its use implies a very definite attitude toward unsolved problems worthy of wider imitation, and that is that it is better to look intently and measure what you see than it is to argue or theorize about what must be there. F. F. Lucas' early work on the nature of martensite is a good example. Of recent years he has returned to the study of the size, number, and composition of the fine carbide particles in hardened steel, and the preliminary results announced to various Chapters of the A.S.S.T. indicate that much qualitative metallography is about to be supplanted by a quantitative science.

Magnification at 12,000 diameters and the use of the ultramicroscope is not the limit of fineness, for everyone knows what X-ray crystal analysis has been able to tell about the atomic arrangement. Even though the conclusions drawn from X-ray diffraction patterns usually apply to the *average* of conditions existing in the metal rather than the precise circumstances at a certain interesting spot, the practical and theoretical possibilities of this work have only been scratched. To explain the nature of solid solutions and compounds, and the electrical properties of metal it will probably be necessary to go even finer, to electrons and nucleus, but as yet sub-atomic physics is mostly speculative.

But in addition to this great increase in precision and sensitivity of experimentation, a profound change in viewpoint is clearly to be observed. No longer is metallography a science of static and stable things, since many so-called metastable phases are being studied, and we are at last beginning to think of transformations and decompositions in terms of *rates*. Abroad a great deal of work has been done to map out the mechanism of the aging of duralumin or the hardening of beryllium-copper — important work that is not widely enough known in America. The various effects of the hardening and tempering of steel were early recognized as being due to an interrupted reaction, but until Bain and his associates actually measured some of these rates, and applied the data to the problem of soft spots on quenched steel, we all talked in generalities.

Here again, theory marches with practice, and will undoubtedly aid in solving the important problem of preventing the precipitation of carbide from "austenitic" chromium-nickel steel during long time at high temperature. Precipitation of an insoluble constituent from a solid solution has been recognized as the cause of age hardening of numerous metals and alloys — in fact, it is the prime cause of hardening by heat treatment. The reaction is so common as to lead C. E. MacQuigg to wonder whether a solid solution is not inherently unstable. In this connection try to explain the structure of meteorites. All man-made nickel-iron alloys are single phase solid solutions; heaven-made nickel-iron alloys are enormous crystals in two phases, one nickel-rich, one nickel-poor. The principal difference is that one is infinitely young, the other infinitely old!

Large Castings Improved by Air Cooling

By T. N. ARMSTRONG
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DEMAND FOR ALLOY STEEL CASTings has been so widespread that a number of foundries have been forced to include them in their production. With the increase in demand for alloy castings there has been a corresponding increase in the physical requirements. Many foundrymen have found themselves in the embarrassing position of not being able to meet these specifications merely by making alloy additions to their steels, since it has become a problem of proper heat treatment as well as careful selection of the most suitable alloy steel for the purpose intended.

There is no doubt that, in many instances, alloy castings are being specified for the replacement of carbon steel castings when there is no justification for the change. Also, there is a tendency on the part of the designer (particularly in ship construction) to specify lighter and stronger castings to replace heavy ones of plain carbon steel. Then if the part fails to give satisfactory service the blame is laid at the foundryman's door, whereas the basis of the trouble is that the designer failed to realize he was decreasing the *rigidity* of the part when he was reducing the size.

Fortunately, these instances are the exception rather than the rule. The existing demand for lighter, stronger castings can be met successfully only with alloy steels, and this condition is plainly indicated by statistics of production since the War. About 5½% of the steel castings made in 1920 were alloy; this proportion steadily increased until 1928, and at present is on the order of 1 ton out of every 8.

Some commonly used specifications requiring certain combinations of strength and ductility in the casting can be met by a number of alloy steels after heat treating in the conventional manner, that is, a plain anneal. Other specifications call for such exceedingly high values for both ductility and strength that no matter what alloy steel is selected, it is necessary to resort to some particular treatment.

As is well known, practically all steel castings are subjected to some heat treatment before they are placed in service. The most popular treatment is a single anneal or a single normalize at a temperature 100° to 200° above the critical range — usually 1600° to 1700° F. Some specifications require that alloy castings, particularly those of large size, be subjected to a double anneal. Although there is evidence of an increase in ductility after the second anneal, as shown by the table on page 34; this increase in ductility is usually accompanied by a decrease in strength. The most favorable argument for double annealing in place of single annealing is a greater homogeneity in the microscopic structure.

To obtain the maximum properties in pearlitic castings with 0.30 to 0.40% carbon it is necessary to quench it in some liquid. (It should be noted that this discussion is limited to medium carbon castings of that carbon range, used for naval purposes. While this article is printed by permission of the Navy Department, the opinions advanced are those of the writer and should not be construed to be the official views of the Navy Department.) Liquid quenching is also necessary to obtain the maximum properties derived from the alloys in these

Properties of Large Castings After Heat Treatment

	First Anneal	Second Anneal		Normalized and Tempered
Casting contains 0.30%C, 0.90%Mn, 3.00%Ni				
Elongation	29.0	29.0		30.0
Reduction of area	53.5	55.0		50.0
Yield point	53,250	52,200		54,750
Tensile strength	84,500	82,750		86,500
Casting contains 0.40%C, 0.90%Mn, 0.60%Cr, 1.5%Ni	First Anneal	Anneal at 1300°F.		Normalized and Tempered
Elongation	20.0	28.5		27.0
Reduction of area	28.5	52.5		49.0
Yield point	58,750	47,500		58,000
Tensile strength	103,100	89,500		87,500
Casting contains 0.28%C, 0.80%Mn	First Anneal	Second Anneal		Quenched and Tempered
Elongation	26.5	29.5		26.0
Reduction of area	45.0	51.0		53.0
Yield point	47,350	48,850		71,000
Tensile strength	80,100	83,620		94,150
Casting contains 0.30%C, 0.95%Mn, 1.5%Ni, 0.14%V	First Anneal	Second Anneal	Spheroidized	Normalized and Tempered
Izod impact (10mm. square)	18	28	46	40
Elongation	24.0	24.0	27.5	25.0
Reduction of area	47.0	44.5	55.0	50.0
Yield point	62,250	61,750	68,500	71,000
Tensile strength	97,500	95,500	88,750	92,250

steels. Some few types of small castings can be and are quenched successfully, but as a rule it is impractical to attempt to quench large castings or even small ones having decided differences of section.

Normalizing is considered to be an intermediate step between liquid quenching and annealing, as it is thought of as an "air quench." It does not give the high values obtained by liquid quenching, but does give decidedly better values than obtained by annealing. (See the table for representative values.)

Tempering is considered good practice after normalizing for all steel castings and is essential for most of the alloy steels.

Air Quench Not Dangerous

A treatment which has given excellent properties to carbon steels and a number of the alloy steels consists of normalizing from a high temperature, 1700° to 1800° F., to break up the cast structure, followed by normalizing from slightly above the critical range, 1500° to 1550°, and then tempering at whatever temperature is necessary to meet the ductility requirements, usually 1100° to 1250°. This treatment has been used extensively for small castings but there appears to be considerable timidity on the part of metallurgists and foundrymen in subjecting a medium or large sized casting to such a treatment.

There is a popular belief that such a "drastic" procedure will crack the casting. It is not realized that there is less danger of cracking during this treatment than there is when the same casting cools in the mold. Tendency to crack is reduced to a minimum by preventing the casting from cooling below 600°, except after final tempering (which is done in the furnace very slowly).

Such castings as the rudder frame shown in the illustration opposite have been given this treatment without warping or showing any treatment cracks. This is an excellent example

of a large piece having thick and thin sections.

Some of the higher carbon steels and some of the alloy steels give excellent results after a spheroidizing treatment. It is interesting to note that most of the steels which react favorably to this treatment contain over 0.30% carbon, with the possible exception of some of the vanadium steels. Ordinarily, a spheroidized casting will show a considerable drop in both tensile strength and yield point with an increase in ductility. Consequently, the treatment should be reserved for that class of steel which will be improved both in tensile strength and ductility and in impact resistance.

The program starts with normalizing from a high temperature, 1700° to 1800°, to break up the cast structure. Next normalize for grain refinement at 1500 to 1550. Then anneal for a prolonged time just below the critical range, usually 1250° to 1300°, to spheroidize the cementite.

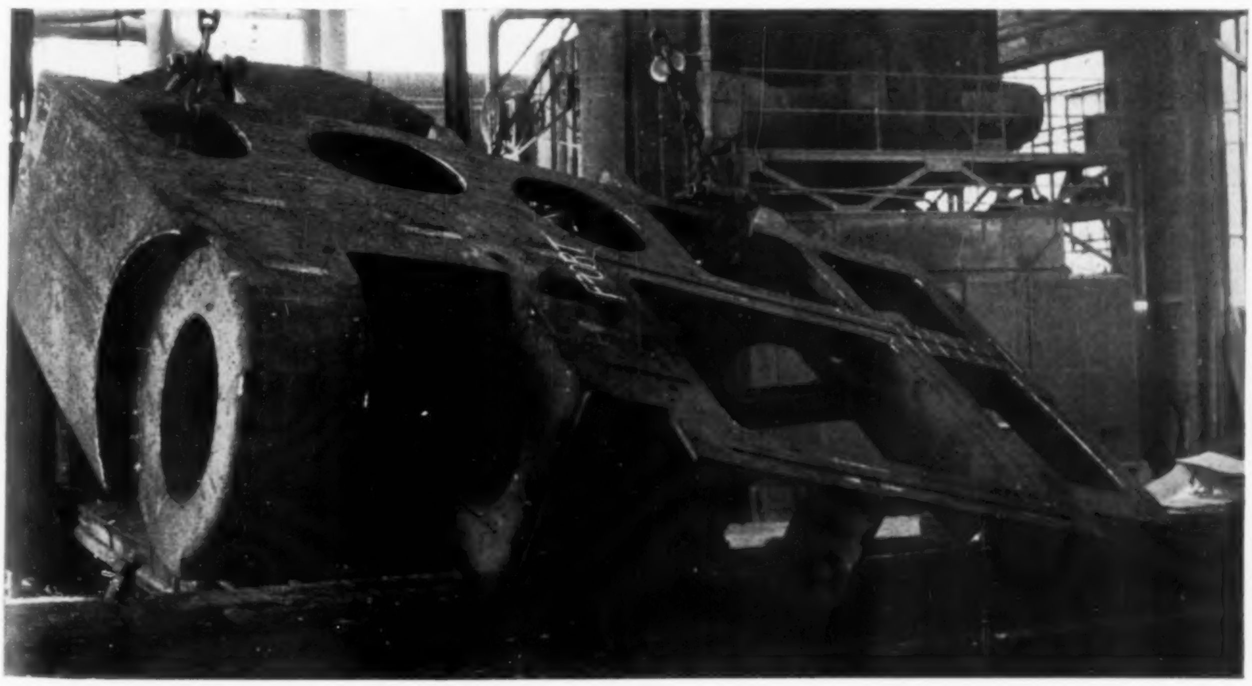
It must be borne in mind that different steels react to this treatment in different ways, and while the ductility values are nearly always increased the strength may be lowered considerably. Note the last set of figures in the table on the opposite page.

Improving the Ductility

In making steel for high strength castings it is not unusual to find that the steel will more than meet the strength requirements but have less than the specified ductility (that is, elongation and reduction of area) after an annealing or normalizing from above the critical range. A successful softening treatment is an anneal just above the lower critical temperature (Ar_1 point) and within the critical range, usually 1325° to 1375° F.

It is futile to attempt to establish any one treatment to obtain the maximum properties of a number of different classes of steel castings, as each class possesses certain characteristics which differ from those of any other class. Maximum strength and maximum ductility cannot be obtained at the same time with the same treatment. There are certain treatments, however, which will give maximum strength and best ductility. There is little doubt that double normalizing and tempering, and in certain instances spheroidizing, are treatments for steel castings which will increase rapidly in popularity as soon as the foundryman realizes their practicability and value.

13-Ton Rudder Frame Cast of 0.30% Carbon 3% Nickel Steel. It has been double normalized and tempered. Stern posts for light cruisers weigh 43,000 lb., are cast of electric alloy steel and subjected to complex heat treatments



The March of Platinum in Industry

By EDMUND M. WISE
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Discovery of platinum and the birth of applied science were so nearly coincident, and their paths of development have been so interdependent, that a chronicle of the uses of platinum draws an accurate picture of the progress of science in industry. Innumerable experimenters, from Faraday to Edison, have either studied platinum or have used it in their inventions which have exercised so important an influence upon our present mode of living.

A strange ore came from Colombia in the New World during the middle of the 18th century. It was called *oro blanco* or *platina* (little silver), but was not of interest to gold seekers due to its refractory nature. Chemists promptly began to unravel its complexities. It was found to be soluble in aqua regia and that a new metal could be precipitated from such a solution by potassium or ammonium chloride. Today this method continues to be used for the commercial refining of the metal. Charles Knight produced platinum on a commercial scale in 1800 by welding or sintering platinum sponge — a method used a century later to make ductile tungsten.

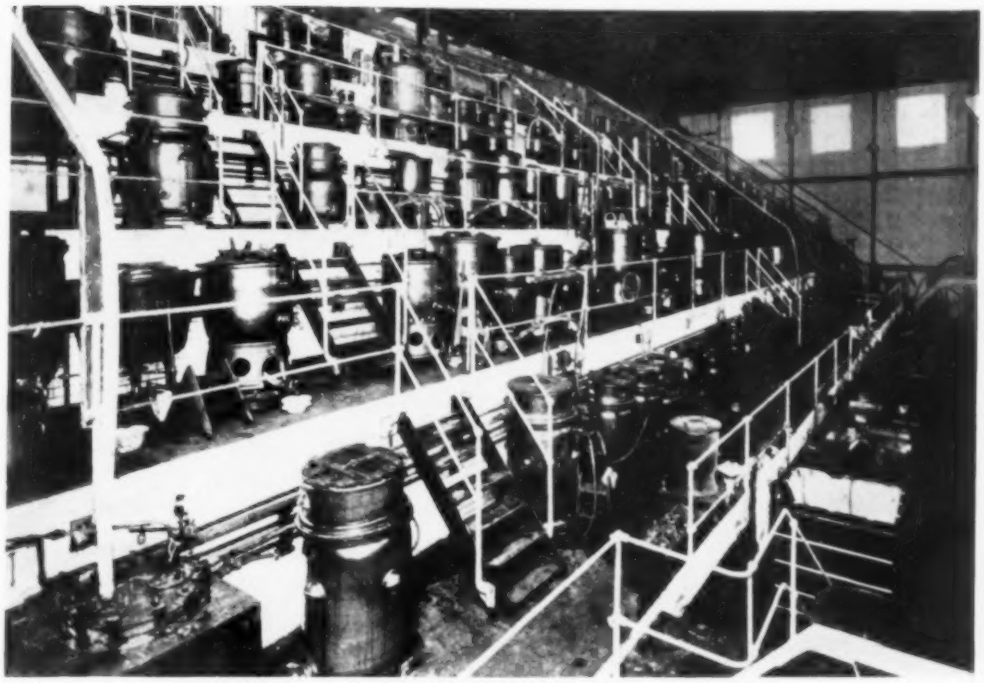
Dr. Wollaston (perhaps the most important name in the history of the platinum metals) found that the metal which had been called platinum was not a simple substance but contained several closely allied metals. This led to his announcement of the discovery of palladium and rhodium in 1804. Osmium, iridium, and ruthenium were discovered by others shortly thereafter.

The technique of producing massive platinum was also greatly advanced by Wollaston, who developed Knight's sintering process on a commercial scale and built up quite a profitable business in refining platinum and in producing it in wrought form. In the course of this work, he devised a method for drawing ultra-fine platinum wire by coating a moderately coarse wire with silver, drawing the composite wire to a small size, and then removing the silver coating by acid. By this method wires as fine as 0.00005 in. diameter can be produced, and were later to become of importance in the electrolytic detectors for early radio apparatus.

The fusion of platinum became possible through the invention of the oxy-hydrogen blow-pipe by Robert Hore, and in 1836 he recounted his experiences in melting platinum in quantities of 28 oz. Pioneer firms in England, Germany, and the United States actively entered into the refining and fabrication of platinum articles on a commercial scale during the latter half of the nineteenth century, and made this metal generally available in its diverse commercial forms.

Chemists were early awake to the unique properties of platinum as a corrosion resistant metal and as a catalyst. In fact, as early as 1812, Davy suggested that platinum sponge would be a suitable catalyst for the oxidation of sulphur dioxide to produce sulphuric acid, and in 1831 this suggestion was tried on a commercial scale. In 1875 the use of purer SO_2 led to success. The equilibrium relations in-

Wet Process Equipment in World's Largest Platinum Refinery, Operated by Mond Nickel Co., Acton, England



volved in this process were thoroughly investigated so that this platinum catalyst has become firmly established in the industry for the production of high purity sulphuric acid. Large quantities were also employed for evaporating pans used for concentrating weak sulphuric acid made by the chamber process.

Production of nitric acid by the catalytic oxidation of ammonia on platinum became commercially important in 1903. With the success of Haber's synthetic ammonia process, this method of producing nitric acid became so successful that it has well nigh supplanted natural nitrates as a source of nitric acid and is competing with them for fertilizer.

The ammonia oxidation unit employs a catalyst gauze woven preferably from a rhodium-platinum alloy. This gauze, usually multi-layer, is in the form of a flat pad or a cylinder through which the mixture of ammonia and air passes. The gauze attains a temperature as high as 1650° F. in service, but platinum alloys withstand high temperatures so well that a single catalyst unit will produce upwards of 4,000,000 lb. of nitric acid before repairs are needed.

Many other reactions catalyzed by platinum have received attention, notably the hydrogenation of unsaturated hydrocarbons. At present, however, most of the 600,000,000 lb. of oils and fats hydrogenated each year in the United States are treated with nickel, rather than platinum or palladium, although some palladium is being very successfully used for the complete hydrogenation of special products.

Chemists early adopted platinum for crucibles, and later for electrodes employed in electrolytic analysis and also for the windings of furnaces used for combustion reactions. The advance of the rayon industry required a metal extremely resistant to corrosion and one which could be accurately drilled with hair-fine holes. Platinum alloys were promptly developed for this, and are today in almost universal use for this important service.

Makes Best Thermocouples

Platinum metals have been indirectly very important to metallurgists, who have been provided with a convenient and accurate means for measuring high temperatures through the discovery by LeChatelier of the excellent rhodium-platinum vs. platinum thermocouple. This thermocouple is to the metallurgist what the balance is to the chemist, and constituted a great forward step toward placing metallurgy

on a quantitative basis. Were it not for the platinum thermocouple, not only as a laboratory standard but also as a working tool, our high temperature operations would be far less extensive than they now are, and many important advances, not only in the metallurgical but also in the ceramic art, would have been delayed for years.

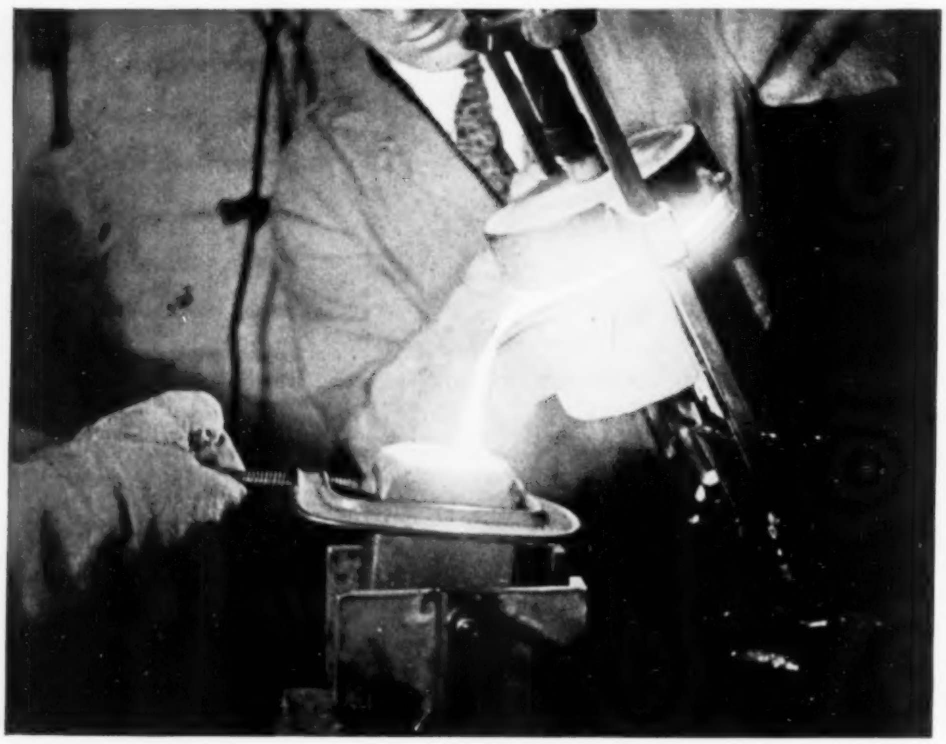
Thermocouple protection tubes have been vastly improved both with respect to gas tightness and resistance to thermal shock and have thus greatly extended the applications of the platinum thermocouple. Furthermore, it has recently been found that heavy gage platinum couples could be operated in direct contact with molten glass, so that means are now available for accurately controlling the temperature of continuous glass melting furnaces — a simple solution of a vexing problem.

Alloys of the platinum metals received little attention in the early years, but as methods for purifying and melting platinum improved, the purer and softer metal was sometimes too soft for the intended use. It was then found that relatively small quantities of iridium, when alloyed with platinum, hardened it greatly, and this metal became the standard hardener. Much later, it was found that others of the platinum group metals, such as rhodium and ruthenium, were suitable hardeners. These strong, high melting point, corrosion resistant alloys were very generally used for diverse purposes and were adopted by dentists at an early date for pins to support artificial teeth and for constructing more elaborate dental restorations. During the World War, when platinum became scarce, other alloys containing palladium, platinum, and gold were developed. These alloys, like platinum, can be fired directly into the porcelain at temperatures as high as 2400° F.

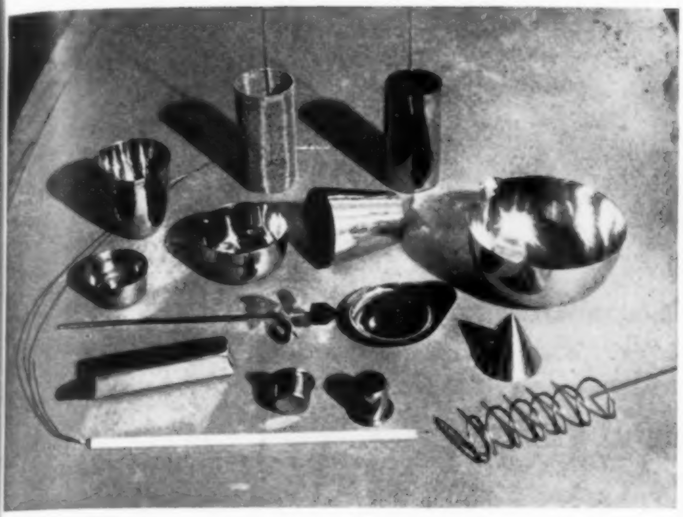
From time to time, platinum was used for hardening the gold alloys employed for jewelry and dental purposes, but it was not until quite recently that the fact that they could be hardened by heat treatment became generally known. Such alloys, which will develop strengths as high as 180,000 lb. per sq.in., are now being widely employed for dental purposes. With the increased availability of palladium, white alloys suitable for dental use have been developed and these are now being adopted in situations where their inconspicuous white color, moderate cost, and excellent properties render them desirable.

Prospectors in remote corners of the earth discovered several small deposits of a very hard, granular, metallic substance possessing extraordinary resistance to acids. It was found that this was a natural alloy of platinum group metals, largely osmium and iridium. It proved to be the ideal material for tipping the nibs of gold pens, where a metal possessing extreme resistance to ink corrosion and abrasive wear is essential. In fact, these alloys have rendered the fountain pen practical.

Casting an Ingot of Platinum



Development of the electrical industry provided many new uses for the versatile metal platinum. It was required for contacts, standard resistors, and electrodes, some of these uses being of considerable magnitude. For instance, Edison recounts that his laboratory supply of platinum was greatly augmented by



Group of Platinum Laboratory Ware

the gift of a number of Grove cells. These cells were equipped with a platinum electrode immersed in nitric acid as a depolarizer, and for many years were in general use supplying current for telegraphs and laboratory work.

The invention of the telephone brought further uses of platinum for contacts; it has grown to large proportions and now takes many thousand ounces of platinum's ally, palladium, each year.

The successful incandescent lamp was the result of a long quest, during many stages of which platinum did unique service. De LaRue in 1820 constructed what was perhaps the first lamp of this kind and used a platinum filament in a glass tube. Edison's carbon filament lamp was a brilliant success, but, paradoxically, it created a most active demand for platinum, for this metal was essential to gas-tight seals of the lead-in wires. A shortage of platinum was actually in prospect until platinum-clad and copper-clad wires of nickel-iron alloy were produced which possessed a coefficient of expansion sufficiently close to that of glass to be acceptable.

Physicists had been busily investigating the mode of conduction of electricity through gases, employing tubes with platinum lead-in wires and electrodes. Röntgen, working with one of these tubes, made the accidental and startling discovery that barium platinocyanide would fluoresce when brought near such a tube, even though the latter were covered with paper or with thin sheets of metal wholly opaque to visible light. He thereupon had discovered X-rays, which have since proved to be so important to the surgeon, the scientist, and the metallurgist.

Röntgen followed up this discovery with others and found that the efficiency of the tube was greatly improved if a platinum target was employed, and for many years this was the standard construction. Some of the tubes were equipped with a side tube of palladium to be heated in the flame of

Spinning a Platinum Crucible

an alcohol lamp, thereupon permitting hydrogen to diffuse through the metal into the X-ray tube in quantities sufficient to lower the vacuum to the desired extent.

Wehnelt found, in 1904, that a lime-coated platinum filament is an excellent emitter of what we now know as electrons, and this type of filament has been widely used in the thermionic amplifier tubes which have made radio and long distance telephony possible. Today much of the excellence of long distance telephony is due to the use of thousands of these amplifying tubes with platinum filaments, and the millions of relays with palladium contacts.

When the mechanical engineer, in his search for a new and better source of power, was developing the internal combustion engine, he found in

platinum a suitable material for constructing the tubes required for the hot tube igniter. Shortly after this, electrical ignition became popular, at first in the form of the make-and-break ignitor, which required very hard platinum metal contacts akin in composition to the osmium-iridium alloys used for tipping gold pens. Then came high tension ignition, requiring iridium-platinum contacts in the spark coil or the high tension magneto. Platinum was ultimately replaced by cheaper metals in the battery ignition systems, but recent experiments indicate that certain palladium alloys may be utilized with great success in this type of ignition equipment. Platinum is the standard contact metal in the high tension magnetos used on aircraft, where reliability is all-important.

Very recently one of the rarer platinum group metals was found suitable for surfacing metal mirrors, due to a high reflectivity and freedom from tarnish. A number of these searchlight reflectors, 60 in. diameter, have been made for the Army and a number are now being made for the Navy. Some 3000 small reflectors of this type are employed in lighting the stage at Radio City.

The above account contains many instances of the temporary use of platinum and its associated metals — where they did yeoman service until special alloys of less costly metals could be developed. Frequently, such substitution is impossible or undesirable. The result has been a fairly steady and increasing demand. New sources of platinum were sought and extensive alluvial deposits were discovered in 1825 in the Ural mountains. These deposits have since constituted the largest single source of platinum.

The Choco district in South America, where platinum was first discovered, has been actively worked in recent years and now contributes an important share. Extensive deposits were also discovered in South Africa and became productive in 1921. Some of them are very rich while others, though extensive, are of much lower grade and constitute a tremendous reserve which can be economically tapped when the price and demand require.

The ores of the Sudbury district of Canada were long known to contain platinum and palladium, and substantial amounts were recovered incidental to the refining of the nickel and copper derived from these deposits. Changes in the refining processes and the development of the great Frood Mine by the International Nickel Co. have so increased the importance of this source of platinum metals that it now ranks second as a source of platinum group metals and first as a source of palladium. As a part of these developments, the platinum refinery of the Mond Nickel Co., at Acton, England, was enlarged so that it is now the largest in the world and is turning out the component metals in the form of sponge of exceptional purity.

The price of platinum has varied considerably during the past 150 years — the crude metal having sold as low as $1 a pound in the eighteenth century and at some $8 per pound at the beginning of the nineteenth. The price rose to about $5 per ounce in the sixties, and to $45 in 1914. During the World War the price reached about $150 per ounce, while it is currently quoted about $33 to $35 per ounce.

Native platinum was used for personal adornment by the pre-historic Peruvians, but it was only during the present century that uses for jewelry assumed importance. It was perhaps initiated by the observation that diamonds mounted in platinum presented a vastly better appearance than those mounted in gold. The properties of the metal itself — its whiteness, strength, and nobility — uniquely adapted it to this use. Later, the increased price of platinum made the metal even more attractive for jewelry, so that today it is firmly established in the fine jewelry industry. In fact, this industry is the largest single user of platinum, consuming as it does some 50,000 to 100,000 ounces of platinum per year in the United States alone.

Perhaps the foregoing account of the uses of platinum has given some conception of the diverse properties and potentialities of this metal and will suggest new ways in which it can serve the growing needs of industry. In this connection it may be noted that the remarkable inertness of platinum and the rhodium-platinum alloys to oxidation at very high temperatures is now being recognized and is leading to new industrial applications where refractories and base metal alloys have proved inadequate. It seems probable that numerous other applications to high temperature process and corrosion resistant equipment will develop.

ALCOA

Re-Design

is a problem sitting on the doorstep of most manufacturers

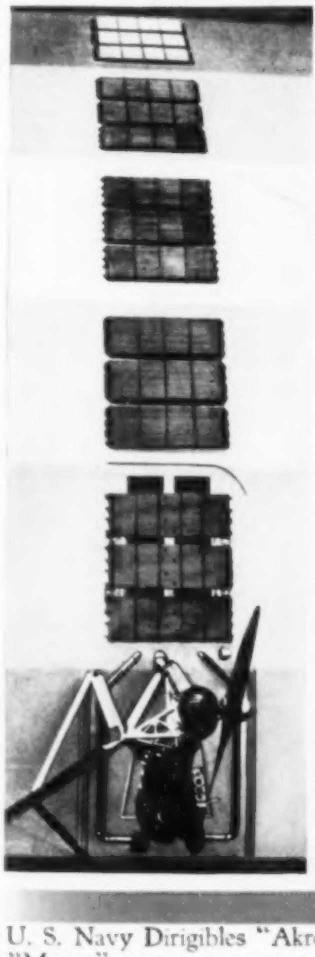
Basic Materials and Good Re-Design

"In the coming era of business revival, which will be the greatest period of re-design the world has ever known, aluminum will play a large and significant part. It will be the basic material in thousands of products.

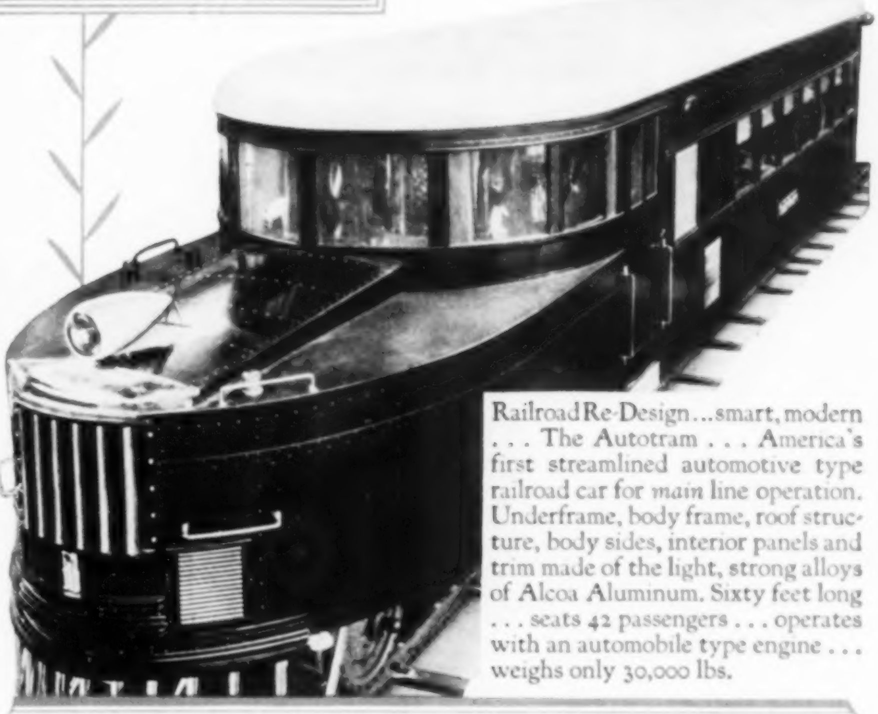
"The immediate future of industry and science will witness a sharp and decisive battle against mere weight. The public, its buying power revivified, will demand beauty of form, new efficiency of performance and durability.

"I have found that Alcoa Aluminum, because of its great tensile strength combined with its light weight, its resistance to corrosion and its ready applicability to countless shapes, serves the designer's aims perfectly in creating many new articles or recreating old ones of greater utility, beauty and salability."

Re-Designed, this feather weight iron ... weighs only 3 lbs. Has better heat conductivity because sole and pressure plate are made of a single Alcoa Aluminum Casting, with heat unit cast as insert.



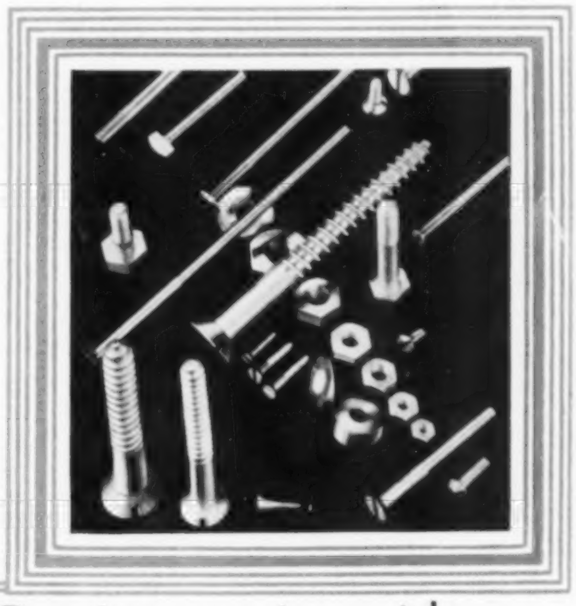
On U. S. Navy Dirigibles "Akron" and "Macon", water recovery tanks made of Alcoa Aluminum streamline tubing are employed to condense engine exhaust gases . . . water so condensed is stored and thus, compensating for fuel used by engine, serves to equalize weight of ships.



Railroad Re-Design...smart, modern . . . The Autotram . . . America's first streamlined automotive type railroad car for *main* line operation. Underframe, body frame, roof structure, body sides, interior panels and trim made of the light, strong alloys of Alcoa Aluminum. Sixty feet long . . . seats 42 passengers . . . operates with an automobile type engine . . . weighs only 30,000 lbs.

What Customers want . . . is the reason for the vast shift to ALCOA ALUMINUM

Maker of Wallboard re-designs it . . . using Alcoa Aluminum Foil. *Foiled*-wallboard insulates, because heat bounces back from the bright surface of the foil . . . stays *inside* the structure in Winter . . . stays *outside* in Summer.

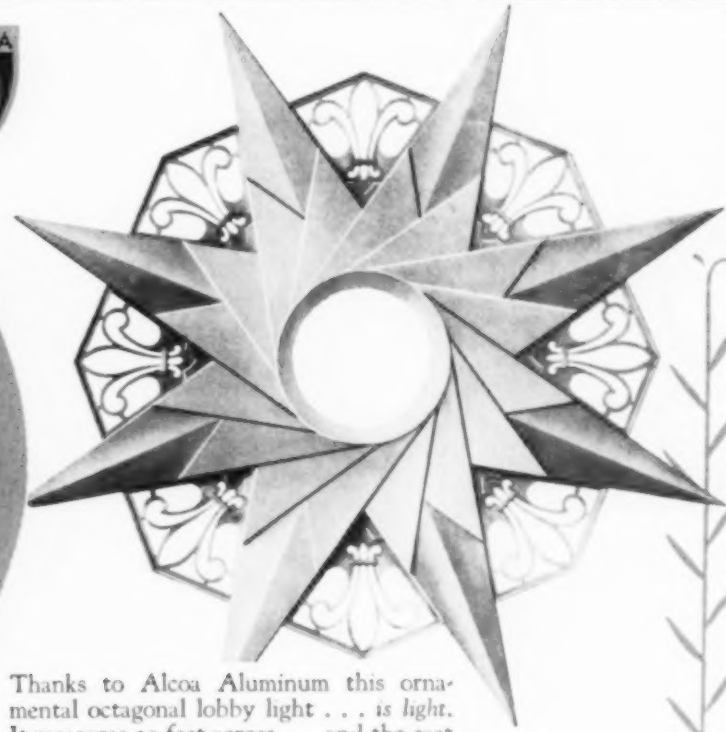


Screws, Buttons, Bolts, Nuts made of Alcoa Aluminum, are the equal in strength of other metals commonly used, but only ⅓ as heavy . . . perfect in fit . . . resistant to corrosion.

Product Re-Design, using Alcoa Aluminum, has pulled many Products out of Sales Doldrums

ALCOA

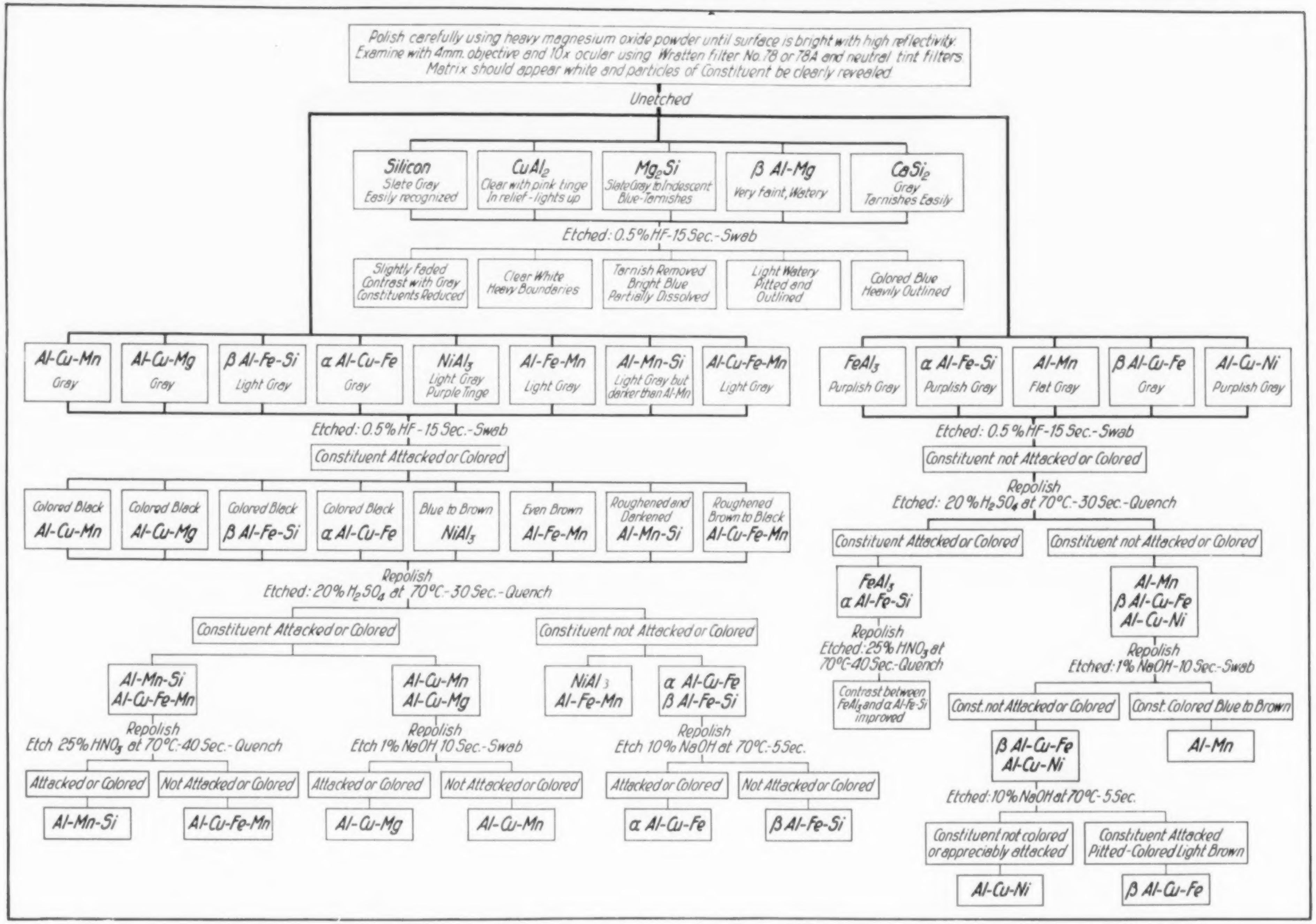
In the front. Chimney shields for the newest Radio Tubes made of Alcoa Aluminum meet needs of rigidity, springiness, and smart appearance. In the back. Alcoa Aluminum Extruded Cans for Radio Electrolytic Condensers . . . Shape cannot be obtained economically except by impact extrusion process . . . threaded neck means easy mounting.



Thanks to Alcoa Aluminum this ornamental octagonal lobby light . . . *is light.* It measures 10 feet across . . . and the cast aluminum plates were filed, polished to a satin finish and lacquered.

Using the many light, strong alloys of Alcoa Aluminum it is possible to secure great strength with extreme lightness . . . to get a metal that is highly resistant to corrosion . . . that is bright and an excellent conductor of heat and electricity. Cost is low compared to other metals not possessing *all* these specific advantages. Quick delivery from warehouse stock in principal cities. Ask for the name of your nearest distributor. For information on how to use, form or handle Alcoa Aluminum in any way write us. ALUMINUM COMPANY *of* AMERICA; 2501D Oliver Building, PITTSBURGH, PENNSYLVANIA.

IDENTIFICATION OF CONSTITUENTS IN COMMERCIAL ALUMINUM ALLOYS



By F. Keller and G. W. Wilcox, Aluminum Research Laboratories (After Dix and Keith, With Additions).

Polishing & Etching of Constituents of Aluminum Alloys

By F. KELLER and G. W. WILCOX
Aluminum Research Laboratories
New Kensington, Pa.

A SYSTEMATIC GUIDE FOR IDENTIFYING the constituents occurring in aluminum alloys is presented as a data sheet on the opposite page, with the idea that it will prove useful to metallographers. It is similar to the one suggested by E. H. Dix, Jr., and W. D. Keith before the American Society for Testing Materials in 1926, except that a number of new constituents have been added.

The constituents are found in a eutectic network in "as cast" alloys and distributed at random throughout the matrix in wrought alloys. Some of the more common, such as $CuAl_2$, silicon, Mg_2Si, and β Al-Mg can be identified quite readily by their polishing characteristics, color, and manner of occurrence. Others, however, are sometimes present that are more difficult to identify and necessitate the use of etching reagents.

In general, the constituents occurring in aluminum alloys are of the following nature: (*a*) Elements that do not form compounds with aluminum and therefore are present in the primary state; (*b*) elements that form intermetallic compounds with aluminum; (*c*) intermetallic compounds formed by two or more elements other than aluminum and which are stable in aluminum (for example, Mg_2Si); (*d*) ternary or more complex constituents.

Obviously, the first step is to polish the specimen. The preferred method used in the Aluminum Research Laboratories is carried out in the following order:

(*a*) Microtome cut to provide a truly plane surface.

(*b*) Polishing on a rotating disk at about 300 r.p.m. using a "kitten's ear" broadcloth pad and No. 600 alundum.

(*c*) Final polishing on a rotating disk at about 150 r.p.m. using heavy magnesium oxide powder on a "kitten's ear" broadcloth pad moistened with distilled water.

When a microtome is not available the plane surface can be obtained by rubbing on a mill file. This operation can be followed by hand polishing on 0, 00, and 000 metallographic emery paper in the order named. Operations (*b*) and (*c*) can then be carried out.

Six etching solutions are in general use. These are all aqueous solutions made up by volume when acids are used, and by weight in the case of sodium hydroxide. Their designation and manner of use are as follows:

1. 0.5% hydrofluoric acid. This is applied by swabbing the specimen with a soft cotton swab for 15 sec.

2. 1% sodium hydroxide. This should be applied by swabbing for 10 sec.

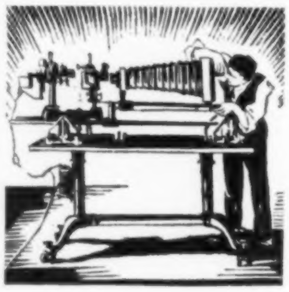
3. 10% sodium hydroxide used at a temperature of 70° C. (160° F.). The specimen should be immersed for 5 sec. and rinsed in cold water.

4. 20% sulphuric acid used at a temperature of 70° C. (160° F.). The specimen should be immersed for 30 sec. and quenched in cold water.

5. 25% nitric acid used at a temperature of 70° C. (160° F.). The specimen should be

immersed for 40 sec. and quenched in cold water.

6. HF-HCl-HNO_3 mixture, containing 1.0% hydrofluoric acid, 1.5% hydrochloric acid, and 2.5% nitric acid. The specimen should be immersed for 10 to 20 sec. and washed in a stream of warm water. (This reagent is specifically recommended for developing the grain structure of alloys of the duralumin type such as 17ST and Alclad 17ST as well as for all aluminum-copper alloys. See a paper published in *Mining and Metallurgy*, July, 1928, by E. H. Dix, Jr., and F. Keller.)



Two methods of etching are in common use — by immersion and by swabbing. The practice of swabbing with a dilute solution of hydrofluoric acid or sodium hydroxide has been found to give uniform and satisfactory results, particularly in the preparation of surfaces for photomicrography. Experiments have shown that the temperature of both specimen and etching reagent, the concentration of the solution, and the time of etching should be controlled to give uniform results.

Methods of Identification

The first attempt to identify the constituents should be made on the unetched specimen, using color and manner of occurrence as a means of differentiation.

For judging the color it is advisable to employ light approximately the color of daylight. Addition of an Eastman filter No. 78A (which has a bluish tint) converts the light of a 5-amp. carbon arc with Eastman neutral tint filter to approximately that of daylight. Any white light will give about the same results, although the bluish tints aid in the separation of different constituents.

Examination at a magnification of 500 diameters using a 4-mm. objective and 10× ocular is recommended.

The effect of the various etching solutions on the 20 different constituents found in aluminum alloys is given in the data sheet published in February. The systematic guide given on page 44 of the present issue is somewhat tentative, as it is subject to all the limitations of any etching procedure. It should prove adequate in a majority of cases as a means for identification, even though the composition of the alloy is not known. In general, the work is simplified if the approximate chemical composition is known. However, by following the guide, a good idea of the alloy type or composition may be obtained.

It should be recognized that the constituents are not easily identified without the background of experience gained through the examination of alloys containing known constituents. For those interested in the metallography of aluminum alloys the value of a set of standard specimens cannot be overestimated. Such a set of 20 alloys has been made at the Aluminum Research Laboratories, using high purity metal (99.95% Al) to which only the purest alloying elements were added. In these alloys the characteristic constituents occur without the presence of others arising from the impurities existing in commercial ingots and alloys.

The chemical compositions of the 20 special alloys used to develop the individual constituents are as follows (wherein the figures represent the weight percentage of metals other than aluminum in their respective orders): Silicon, 12.89; Mg_2Si, 19.63:11.53; $CuAl_2$, 6.54; β Al-Mg, 10.21; $FeAl_3$, 6.65; α Al-Fe-Si, 1.49:4.47; β Al-Fe-Si, 11.88:7.67; Al-Mn, 3.08; $NiAl_3$, 4.00; Al-Fe-Mn, 1.34:1.52; Al-Cu-Ni, 4.00:4.00 (nominal composition); α Al-Cu-Fe, 1.00:1.00; β Al-Cu-Fe, 2.50:1.00; Al-Cu-Fe-Mn, 4.00:0.50:0.60; Al-Mn-Si, 2.12:1.82; Al-Cu-Mg, 4.16:5.47; $CaSi_2$, 1.50:2.10; Al-Cu-Mn, 8.99:1.07; $CrAl_7$, 1.41; Al-Cr-Fe, 4.00:4.00.

A series of seven plates has been prepared and will be published in a subsequent issue of METAL PROGRESS showing the identical particle of constituent, unetched and after etching with each of the six solutions previously described. These photomicrographs are all at a magnification of 500 diameters. They should serve as a means of reference for determining the appearance and separation of the different constituents when using the etchants described.

Correspondence and Foreign Letters

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Advantages of Soderberg Electrodes

TURIN, ITALY — Rapid developments and increasing use of the self-baking "Söderberg" electrode in Europe are worthy of note.

The two largest European electric steel plants — the Aosta works in Italy, and the Ugine works in France — have used Söderberg electrodes exclusively for many years in their 20 to 30-ton furnaces. Other important producers (as, for instance, the Acciaierie & Ferriere Lombarde in Italy) have completely replaced the graphite electrodes with the Söderberg electrodes in their large furnaces.

Similar advantages to those noted below have been found in other types of furnaces, as well as in the manufacture of different products. Statistics from the principal Italian electrometallurgical industries show the relative development of the Söderberg electrode at present. In the production of ferro-alloys 25 furnaces with 62 electrodes consume 70,500 kva. of energy. Eighteen furnaces with 31 Söderberg electrodes are making calcium carbide, using 39,500 kva. For steel making, 13 furnaces with 33 such electrodes consume about 49,000 kva. of electrical energy.

One of the important points in comparing a self-baking electrode with a graphite electrode for a steel furnace is that the latter not only *can* be made of a smaller diameter than the former (on account of its higher electric conductivity) but *must* be so made on account of the practical difficulty of graphitizing, without ruinous breakage, a carbon of very large diameter (say 2 to 3 ft.). Aside from this factor, the great advantage of a large electrode, especially when smelting scrap in a large furnace, is that a much larger surface comes into contact with the charge. This distributes the heat much better throughout the whole furnace, avoiding the localized overheating and melting which is typical of a scrap charge melted in a large furnace with graphite electrodes.

The most important consequence of the better distribution of heat is a very substantial shortening of the melting and refining operations. This fact has always been ascertained by the European steel works which have replaced the graphitized carbons by the large self-baking ones, and is responsible for great economies in the current, refractories, electrodes, and ferro-alloys used.

These circumstances make for a much lower cost per ton of steel produced and explain the fact that, with very few exceptions, the large steel furnaces in Italy are equipped with Söderberg electrodes. The majority of small furnaces (3 to 5 tons) and the medium sized ones (5 to 10 tons) use natural graphite electrodes made by the "Società Talco e Grafite di Val Chisone."

Several recent improvements in the apparatus for the continuous and automatic lowering of the carbons have spurred this general adoption of the self-baking continuous electrode. Other important developments are carbons of oblong cross-section, the application of the safety "wisdom ribbon," the use of water-cooled flexible cables, and above all the improvement in the quality of the paste and in the

Correspondence and Foreign Letters

design of the steel ribs, which permit a great increase in the current density.

Mr. Söderberg is now studying the applications of his electrode to the aluminum industry. The first results of large-scale experiments seem to be extremely encouraging. The same may be said of the experiments on exceptionally large sizes — 13 to 14 ft. in diameter — such as are required in the Miguet furnaces. The excellent results obtained in the last few months in Italy with new Miguet furnaces of large capacity render these new researches extremely interesting.

FEDERICO GIOLITTI

F Scale for Thin Brass

WATERBURY, CONN. — On reading M. H. Medwedeff's excellent article on "Workability of Brass" in the February issue of METAL PROGRESS, I noticed one small inaccuracy in nomenclature, to wit: The heading of the table on page 21 should be "Rockwell F Hardness" and not "Rockwell B Hardness." The makers of the Rockwell instrument have assigned the letter F to designate the scale resulting from the use of $\frac{1}{16}$-in. ball with 60-kg. load (and this loading is plainly stated in the subtitle of the table mentioned). The B scale applies only to $\frac{1}{16}$-in. ball, 100-kg. load. This relatively new F scale is particularly suited to tests on thin sheet and strip material, such as brass. A description of the seven Rockwell scales now accepted for various classes of metal articles is given in a section prepared by the writer for the forthcoming edition of the American Society for Steel Treating's National Metals Handbook.

ALVAN L. DAVIS

Weathered Steel Resists Corrosion

BIRKENHEAD, ENGLAND — Corrosion is such a complex subject that one is hardly surprised at the sudden appearance of a new and troublesome manifestation. That is what has happened in the shipping industry, where corrosion troubles are always with us.

In the early days of the steel ship the double bottom tanks were mainly used for purposes of trim in the ship. They were or were not filled with sea water according to the demands of the nature of the cargo carried. On occasion certain tanks were filled with fresh water for drinking purposes or for boiler consumption. In the former case protective coatings in the nature of cement wash were applied, and in the latter case various greases of the solid and semi-solid variety were used with more or less success.

During the War, however, it was found that where stability conditions did not interfere it was possible to convey valuable liquid cargo, particularly fuel oils, in double bottom tanks.

So far as British ships were concerned this cargo was only homeward, and it followed that on the outward trip stability conditions might necessitate filling with sea water tanks that had previously held fuel oil. For some years the opinion was chiefly held that this carriage of oil was highly beneficial to the material of which the tanks were made, and this was probably so, but of late years (and particularly with more modern ships) a somewhat virulent type of corrosion has made itself evident. Pitting is deep and frequent, and paints and greases refuse to adhere for more than a comparatively short time. Many are the remedies which have been suggested and tried — nearly as many as the suggested reasons for the phenomenon!

In the writer's opinion, after investigating a great many cases, the most likely explanation is one tendered by Dr. Montgomery in a paper recently read before the Institute of Naval Architects on "Hull Corrosion." The hypothesis may be briefly stated as follows:

In pre-War days when a charge-hand in a

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shipbuilding yard wanted plates or sections he went to the storekeeper, who went to the rack, got the plates down and handed them over. These plates had probably been in the rack for some time and therefore had had adequate opportunity for weathering, with its consequent detachment of the mill scale. Conditions are different now: Plates are only being rolled as required and are put into service within a very short time after their manufacture. The result is that probably moisture is concealed under the scale and in course of time does its corrosive work.

F. G. Martin

Interrupted Hardening of Carbon Steel

BRIDGEPORT, CONN. — The article by Hans Diergarten on "Graded or Interrupted Hardening" in METAL PROGRESS last month, brought to mind an investigation of the interrupted hardening of 0.8% carbon steel wire 0.192 in. diameter made in the Research Laboratories of the American Chain Co. in 1929 and prior. It was found that this steel, when quenched from 1500° F. into a salt bath maintained at 450° F. was fully austenitic and non-magnetic. The austenite was stable for at least 5 min. and the wire could be readily bent or formed at this temperature, having a hardness of C-25. However, on cooling to room temperature the austenite transformed to martensite of Rockwell hardness C-59 no matter how slowly it was cooled. Transformation at 500 to 600° F. is slower and results in large needles of lower hardness.

It was suggested that this quenching method had definite value to shop practice as it might be used to avoid quenching cracks in tool steel because by slowly cooling after the salt quench (in air, for instance) the whole of the tool would go through the martensitic expansion at one time thus avoiding quenching strains. Also it was suggested that pressing or forming could be done while the metal was soft and austenitic (as, for instance, coiling wire into a spring) after which it would harden as it cooled to room temperature.

A full account of this work was published by the writer in the *Journal* of the Iron & Steel Institute in 1929. This is of interest in connection with Herr Diergarten's article, as he states he could not get satisfactory interrupted hardening with ½-in. disks of plain carbon tool steel, quenched in oil at 480° F. and subsequently cooled in cold water.

Dartrey Lewis

Eye Appeal Helps Metal Partitions

PALO ALTO, CAL. — In a recent tour, the writer was struck by the number of metal buildings used on the ranches and Pacific beach resorts. They included bungalows, garages, small offices, auto camp cabins, wayside stands and catch-penny booths, sheep shelters, poultry houses, rabbit runs, and feed cribs. Some of them were home made and not much of an improvement over a tin-can shanty, but many were of pre-fabricated metal sections, portable and ready-built into an attractive structure. In some designs great ingenuity was shown in adapting metal to an appearance of brick, frame or stone construction; in others the lines were frankly of steel.

These observations and earlier experience not only with metal partitions but the manufacture of metal toys and display signs, convince the writer that the matter of proper protection and decoration is of prime importance and must be adequately solved before any large expansion of sheet metal into these uses is possible. It is more than a coincidence that the best salesman for metal partitions is a man having a flair for

Correspondence and Foreign Letters

decoration. Unfortunately, most of the manufacturers feel that it is impossible to predict the color scheme in any building and the aesthetic taste of the customer. Consequently they are content to ship the partitions or building unit with a tan, gray, or drab ground coat, and many sales are lost because the customer has not the imagination to visualize the attractive surface which can be laid over them.

Much metal partition is bought in this region for installation in shops and factories. While few superintendents would feel that it is necessary to paint baskets of fruit upon the shop walls, it certainly does not decrease the efficiency of the worker nor the eye strain to cover them with geometric forms or conventional designs, boldly executed in harmonious colors. Office enclosures, at least, can be sprayed with aluminum or gold bronzing liquids, with very little additional expense and with great effectiveness.

Metal construction has so many advantages as to durability, fire resistance, and sanitation that the higher first cost over a lath and plaster partition is very often justified. The writer feels that this desirable market for the ordinary grades of sheet steel can be indefinitely extended if more attention is given to its surface. It would be well for the men in this branch of the metal industry to take an idea from the auto body makers. *They* do not depend upon the purchaser to decorate his own car! They are also able to avoid deadly uniformity.

George Rice

Shrinkage — Melt to Cold Metal

SENDAI, JAPAN — It is usual to measure the total shrinkage of a cast bar during cooling from melt to room temperature by means of an extensometer built into the mold. Mr. Keep in America and Dr. Turner in England have led the way in such useful foundry studies. It is very questionable whether this apparatus gives a true value of the shrinkage. Therefore the writer and R. Kikuchi resolved to decide this point by a further experiment with an improved instrument of the Turner type, and arrived at the conclusion that the shrinkage as measured by an extensometer is principally the contraction *after* solidification of the casting.

First, the "total shrinkage" of various metals, such as aluminum, tin, lead, bismuth, antimony, and type metal in the range of temperature from their molten state to room temperature, were measured by our improved Turner extensometer. Next, the contraction after solidification was measured accurately by using the total dilatometer constantly used in our Institute; that is to say, circular rods were made of the above metals, and the expansion of each of them was measured from room temperature up to a temperature near its melting point, at which plastic deformation began. In this way, expansion-temperature curves were obtained for the several metals, which were extended to the melting point to give the total linear expansion in the solid phase. These two sets of results are given in Columns I and II in the table.

Metals	Linear Expansion		Volume Expansion	Solidification Shrinkage	Total Shrinkage
	Extensometer	Dilatometer	3 x Column II		Column III + IV
	Column I	Column II	Column III	Column IV	Column V
Aluminum	2.06%	1.79%	5.37%	6.27%	11.64%
Tin	1.23	1.27	3.81	6.51	10.32
Lead	0.90	0.99	2.97	3.45	6.42
Bismuth	0.22	0.36	1.08	−3.33	−2.25
Antimony	0.58	0.69	2.07	−0.96	1.11
Type metal	0.57	0.60	1.80	1.23	3.03

From this table, it can be seen that for these metals, the linear expansions measured by the dilatometer roughly coincide with those measured by the extensometer. The latter figures also agree satisfactorily with those obtained by

previous investigators by means of extensometers. Hence it is to be concluded that the extensometer used in foundry researches gives principally the shrinkage *after* solidification of these metals, and that it cannot include any of the contraction during solidification. The results are of most importance to pattern makers.

Some years ago Dr. H. Endo and Dr. Y. Matuyama measured the contraction during solidification by means of a thermo-balance. Their results are given in Column IV of the above table. Column III contains the volume expansions of the metals in the solid phase; the figures are merely three times the values in Column II. The last column is the sum of the values in Column III and Column IV, and is the true total shrinkage in volume undergone by these metals in cooling from a temperature just before solidification down to room temperature. Thus the total shrinkage is seen to be much greater than that obtained by extensometers built into test molds.

KOTARO HONDA

Correspondence and Foreign Letters

Surface Effect on Toughness and Endurance

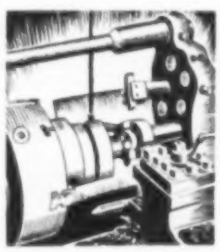
PARIS, FRANCE — In estimating the mechanical properties of a part of given shape and dimensions, only the specific qualities of the metal are generally considered (such as its strength, elasticity, and structure) and one loses sight of the influence of the surface condition. Yet it may modify in a striking way the resistance of the part to shock or alternating stresses. This condition at the surface results from its mechanical preparation or its chemical or thermal history. To realize the complexity of the phenomena, one can consider the sundry actions during the preparation of a finished part. In fact, a double effect may happen — either a modification of the geometrical state or of the physico-chemical or structural condition of the surface.

In either case, we ordinarily think of its influence either on the toughness (resistance to violent impact) or on the fatigue limit (resistance to cyclic stresses). To estimate these effects we must use test pieces whose surfaces are in the exact state which is to be studied and whose resilience and fatigue limit have previously been determined in a standardized condition.

As to *geometrical modifications*, it is well to remember that there is no surface having an ideal polish. Relative degrees of roughness may be defined either by measuring the reflective power by the microscope or by a mechanical recorder such as described by Firestone, Durbin, and Abbott in METAL PROGRESS, April, 1932. The surface is made up of hollows and bosses, the shape, spacing, curvature, and orientation of which are quite variable.

Generally, the resistance to shock and fatigue will decrease as the furrows become sharper, deeper, and in better line with the stresses. For instance, grinding may decrease the resilience when the marks are normal to the length of the test piece. The harmful influence of corrosion on the fatigue limit, when it enlarges pits, scratches, or cracks, is well known. On the other hand, general corrosion may dissolve the edges of grinding marks, and thus remove undesirable "stress raisers." Surface oxidation in the furnace may act in the same manner.

The *physico-chemical modifications* may be merely chemical ones and affect the analysis of the surface (cementation, decarburization or nitriding); they may be physico-chemical changes (such as the effects of tempering and annealing), or else affect the purely physical or mechanical *(Continued on p. 58)*



Concentrates from current literature

ONE of the most useful reference books for any steel maker or student of steel making is **"IRON AND STEEL"** by H. P. Tiemann (McGraw-Hill Book Co., New York). It is called a pocket encyclopedia, and this is a proper subtitle, for if anyone wants to know what this or that process is or what the steel-worker's lingo means, just look in Tiemann. The very comprehensiveness of such a notebook is responsible for the fact that one must use it with discrimination. To give one of a hundred possible examples, the Allis-Andrew process for making thin sheets (which probably never worked) rates five lines, and the Steckel mill (which really rolls thin sheets) is given four. Again: 17 pages of text are used to describe the various direct processes — not a single one commercial as of 1933 in America.

While this new edition has been reset in a new (and smaller) typeface, the changes consist mostly of the addition of a sentence or paragraph here and there rather than a thorough-going rewriting of the 1919 text. Of course this is unnecessary for the standardized steel and iron making processes and for historical notes, but it becomes a serious defect in those sections relating to the rapidly growing subjects of alloy steel, metallography, physical metallurgy, and heat treatment. For instance, the "best modern high speed" steel is quoted as of 1906, with 0.29% vanadium! Nor are the S.A.E. steels even mentioned.

So if you don't own a copy of Tiemann's "Iron and Steel," by all means buy one, but if you have the 1919 edition, it will serve you just as well. Either edition plus the A.S.S.T. "Metals Handbook" will answer 9 out of 10 of the questions which are likely to be asked about metal.

HARDENING of gear teeth can be accomplished with a minimum of distortion by localized heating with an oxy-acetylene flame and quenching by water jets. Equipment for **FLAME HARDENING** developed at the Westinghouse Nuttall plant and described by N. E. Woldman in *Machinery* for February, consists in a double or forked torch providing two flames that heat both sides of each tooth simultaneously. Heating is followed immediately by quenching; one operator handles the torch and another the water jets. If size permits, the gears are then given a strain-relieving draw in an oil bath. With this method only the working surfaces of the teeth are hardened, the gear proper retaining its ductility. Plain carbon steels can be surface hardened to 400 to 500 Brinell, alloy steels as high as 600 Brinell. A railway pinion tooth which was taper ground over an 8-in. length after hardening showed a range of 192 Brinell near the core to 177 at the tooth edge. At a depth of 5/8 in. from the surface, the hardness was 250 Brinell.

AN ANNEALING FURNACE capable of taking drums 17 ft. in diameter and 75 ft. long and heating them to 2400° F. has been built by Sun Shipbuilding & Dry Dock Co., Chester, Pa. As described in *Steel*, Dec. 19, by P. E. Shaver, it is a smooth steel structure, built inside a steel skeleton, and lined with 9 in. insulating brick held to the steel with lag screws. Work is handled on car bottoms; counterweighted end doors are hoisted by motors, and a bulkhead is used to block off unnecessary volume when short work is being heated. Staggered rows of gas burners are installed just above the car bottom and just below the catenary roof; gases are

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withdrawn through a series of dampered openings in the walls about mid-height. These 62 Surface Combustion burners are so arranged that the furnace is subdivided lengthwise into 5 heating zones, each with its independent control valve, operated automatically by pyrometers. When the entire furnace is in operation, the temperature of 16 other points is recorded simultaneously on Brown Instrument Co. equipment. 530-B.t.u. gas at 10 lb. pressure is used; in full operation 38,300 cu.ft. per hr. is burned.

"INDUSTRIAL Electric Heating" by N. R. Stansel (John Wiley & Sons, New York, $5) is largely reprinted from a series of articles in General Electric Review. The first third of the 130 pages contains a comprehensive outline of what is known about the physical phenomena surrounding the generation of heat from electric currents and its control — that is, its insulation and transfer. The middle third of the book analyzes the resistor furnace and its present-day forms adapted to medium high temperature operations such as enameling, **HEAT TREATING,** and copper brazing. (An especially interesting introductory chapter has to do with atmospheric control.) The final portion of the book takes up ferrous and non-ferrous melting, and describes the arc furnace and the induction furnace, both low frequency and high frequency, wherein equal attention is given to the auxiliary electrical equipment. Portions of the subject reserved for a second volume or a second edition are low-temperature baking operations and the various electro-chemical operations such as manufacture of abrasives or ferro-alloys — things which are of minor interest to the metal industry. Taken as a whole, the book appeals to one as being the systematic notebook of a scholarly engineer, well informed about the latest developments in his branch of industry. It therefore becomes an essential working tool for furnace designers, and well worth while for any furnace operator. One great defect in the book is the muddy halftones — they are printed as badly as you might wish, but fortunately few if any of them are necessary to an understanding of the text, which is really illustrated by a wealth of line drawings.

EFFECT of moderate amounts of nickel and chromium in producing a high strength gray cast iron is now well known. Manufacturers of steel mill rolls have also used "balanced" compositions for heavy chill castings. International Nickel Co. has now developed a "Ni-hard" analysis for wear resistant parts, where excessive pressure or impact is not a factor. As described by J. S. Vanick at the February meeting, American Institute of Mining & Metallurgical Engineers, these irons have 2.6 to 3.2% carbon, 0.1 to 1.5 silicon, 3.0 to 5.0 nickel, and 0.5 to 1.5 chromium for maximum strength of core. Maximum hardness of chill (700+ Brinell) requires 3.2 to 3.8% carbon, less silicon, and double the chromium. Clear chill of 4 in. may be had with the former analysis; 1¼ in. with the latter. In foundry production the alloys may usually be added at the spout, or the nickel may be added to the charge and the chromium at the spout, or the latter may be charged in the form of special briquettes. Useful applications have already been made to crusher parts, sand blast nozzles, muller tires, and pump bodies.

AN INSULATED and covered ladle which has replaced the thinner-walled open ladles for transferring and pouring malleable iron at Saginaw Malleable Iron Division of General Motors is described by D. O. Thomas in *The Foundry*, Jan., 1933. By reducing heat lost during transfer from cupola to electric furnace, these **INSULATED LADLES** have reduced the amount of superheat required in the electric furnace from 2900 to 2830° F. Final temperature when the last iron is poured into the mold has been raised from 2540 to nearly 2650° F., the temperature at which fluidity begins to drop rapidly. Pouring ladles of 500 lb. capacity are made with 2½ in. of refractory backed up with 1¼ in. of insulation and a ¼-in. metal shell. The 1½ and 3-ton bull ladles are of similar construction with thicker refractory lining. Al-

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though relining costs 3 and 4 times as much respectively for the new type pouring and bull ladles as for the old, the life has been increased from 1 to 23 days for the 500-lb. ladle and from 4 to 14 days for the $1\frac{1}{2}$-ton ladle.

G. R. Fitterer of the U. S. Bureau of Mines read a paper before the February meeting of the American Institute of Mining & Metallurgical Engineers describing a **THERMOCOUPLE** made of a hollow graphitized carbon with a silicon carbide rod down its center. This has a thermo-electric power 30 times as high as a platinum couple, consequently it will operate very rugged recorders and control instruments. Its top limit of usefulness is not known — it certainly is as high as 1800° C. (3300° F.), 400° C. higher than the platinum couple. The materials are stable and quite resistant to reaction with liquids or gases, and the couple has been successfully used for liquid iron and steel; long immersions did not affect the calibration. Furthermore, couples made in several designs by various experimenters reproduce each other's readings within 1%. A very useful application will be to determine the temperature of a bath of steel before tapping.

A HYDRAULIC testing machine with a capacity of 3,000,000 lb. in tension or flexure and 4,000,000 lb. in compression, which is 65 ft. high, and which can test specimens 33 ft. long and 10x12 ft. in horizontal dimensions has been installed at University of California. It is the world's largest precision **TESTING MACHINE**, according to G. E. Troxell, writing in January *Western Machinery and Steel World*. An elevator completely surrounds it, allowing observers to examine any part of the test, and is connected by telephone and loud speaker with the glass-enclosed instrument and control room. Load is measured at the movable crosshead (point of load application) by a pressure capsule in two units, the upper portion being an integral part of the crosshead and the lower unit a part of the yoke in contact with the test piece. The shallow gap between is filled with oil, which is prevented from leaking by a thin, flexible diaphragm. Application of load causes a slight closing of the gap, and with this frictionless motion, pressure is transmitted undiminished to the indicating dials. Sensitivity of registration of the applied load is within 0.1% at capacity load.

BRINELL hardness of metal while hot may be calculated by pressing two small cylinders into each other and measuring the flattened area. O. E. Harder and H. A. Grove of Battelle Memorial Institute have found the **HOT HARDNESS** of tool steels whose cutting efficiencies had been determined by the Bureau of Standards, and find that the Taylor speed (speed to cause failure in 20 min.) is roughly proportional to the Brinell hardness at 700° C. (1300° F.). A number of commercial tool steels were also tested at various temperatures. At 700° C. the average Brinell hardness of 18-4-1 high speed is about 190; increasing the vanadium to 2% increases the hot hardness to 260 Brinell. High speeds with cobalt measure from 250 to 300. Stellite, while relatively soft at 200° C., retains most of its hardness and measures 150 at 700° C. Since the hardness of high speed steel at 700° C. is less than some of the metal it can successfully cut, the authors suppose that perhaps 650° C. would be a more representative temperature for appraising relative tool efficiency. 600° C. is definitely too low, as shown by tests on the Bureau of Standards' tools. These results were presented to the Iron & Steel Division, A.I.M.E., February meeting.

A CONTINUATION of T. C. Digges' investigations on **MACHINABILITY OF METAL**, which appears in Bureau of Standards *Journal of Research* for January, has to do with work hardening near the machined surface of steel forgings cut with lathe tools. Hardness at the machined surface was greater than the original hardness; changes in cutting speed had no effect, but feed and depth of cut, and composition and heat treatment of the steel influenced

Concentrates

the surface hardness. Tests on ten annealed carbon steel forgings with carbon varying from 0.12 to 1.10% indicated that steels lowest in carbon showed greatest work hardening. Depth of hardening was also greatest in low carbon steels. Other tests on screw stock showed high surface hardness with heavy cuts, and the high work hardening capacity of 18-8 even with small cuts. Annealing the plain carbon and 3.5% nickel steel between 100 and 400° C. (200 to 750° F.) increased the surface hardness, but the effect was removed by heating to 720° C.

TRI-CHLOR-ETHYLENE as a **DEGREASING AGENT** after annealing or oil quenching, before sand blasting, anti-rust processing, or electroplating, was discussed by W. F. Jesson at a meeting of the British Institute of Metals (*Metallurgia*, Dec., 1932). It may be used as either a vapor or liquid bath, the grease and sediment collecting in the bottom or sump of the tank and being removed by distillation at regular intervals. The tank is heated by gas burners and since the tri-chlor-ethylene boils at 87° C., the grease is not vaporized. Solvent can thus be reclaimed and if proper ventilation is provided, loss by diffusion into the air can be kept low. Other advantages are that it dissolves all oils and greases, animal, vegetable, or mineral, whereas alkaline cleaners affect only animal and vegetable oils; unlike carbon tetrachloride (which attacks certain metals in the presence of moisture, particularly aluminum) it is inactive; it leaves no deposit on the metal, as sawdust will; it is not inflammable like gasoline and benzine; it is rapid and simple and is not as unpleasant to handle as boiling caustic soda; and it leaves the work dry, ready for any succeeding process.

"ENGINEERING Shop Practice" by O. W. Boston (John Wiley & Sons, New York, $5.50) is the first of two volumes. In this one the basic machine tools and their attachments are considered — lathe, planer, shaper, milling machine, saw, drill, and reamer. The second volume is to treat screw machines, gear cutters, grinders, presses, and machine shop management. It is apparent that the word "Engineering" has the sense used in England. "Machine Shop Practice From an Engineering Viewpoint" would be a more descriptive title of this first volume. Prof. Boston's work on cutting tools and **MACHINABILITY** is well known, so the reader is prepared for the emphasis placed in this book on the cutting tool rather than the machine for operating it. Fortunately for the non-mathematical reader, the equations of power, feed and speed are reduced to curves, and even better, definite recommendations are given for specific jobs on a dozen or more common metals. As to the machine tools themselves, the illustrations generally are of quite recent date. Little attempt is made to indicate differences between competitive designs, but the major types are classified and the essential features of each subdivision clearly stated. Thus the book tells what can be done with a machine tool after you have it, rather than what manufacturer to buy it from.

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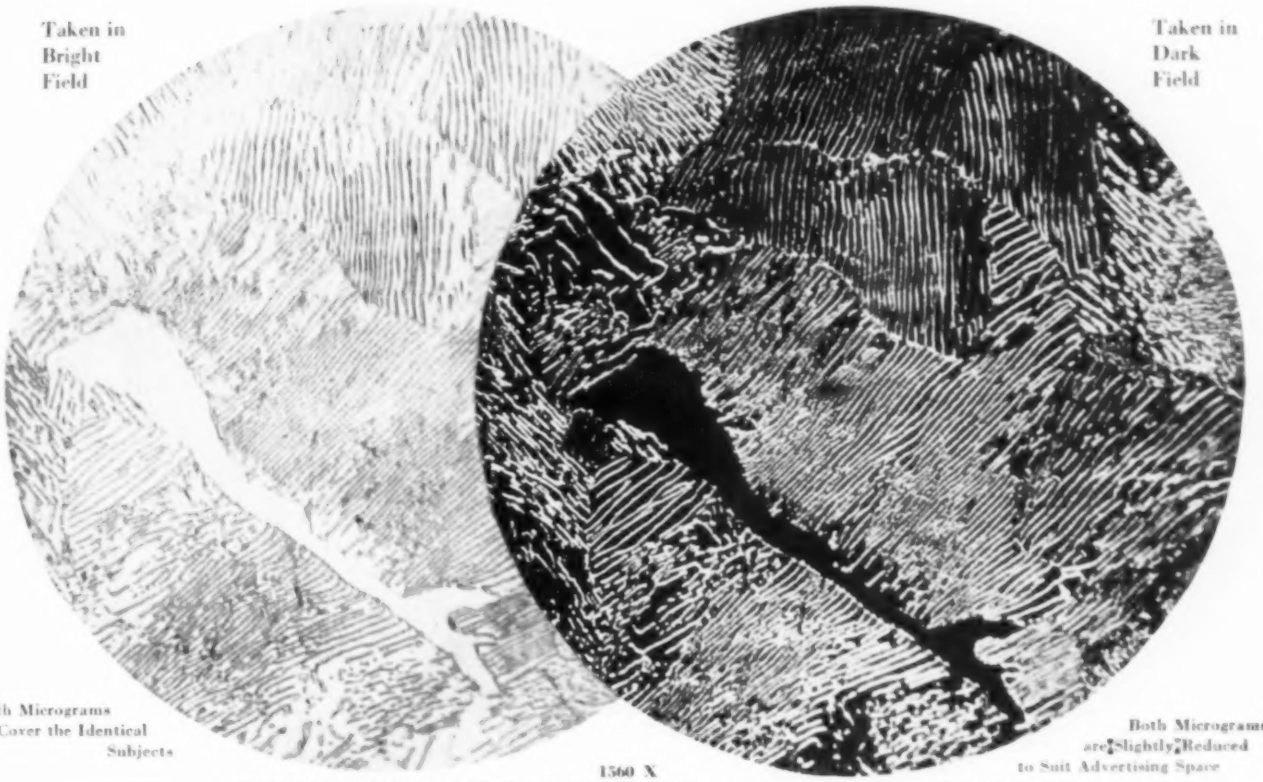

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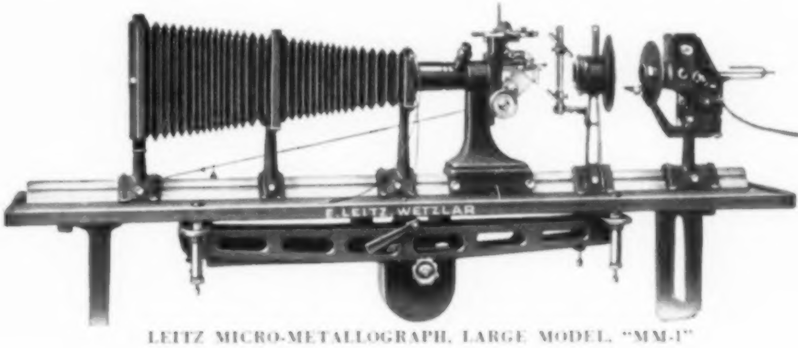

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properties, such as the effects of cold work, recrystallization or coalescence of excess constituent. Each has an influence on the specific properties and particularly on the elastic limit, the elongation, and the capacity for deformation. A lower elastic limit generally lessens the resistance to fatigue. Reduction of the capacity for deformation tends to increase the brittleness, for the surface is inclined to crack under deformation.

Generally, as hardening increases, the elastic limit decreases the capacity of deformation. Opposite effects will be observed on the resilience and the fatigue limit.

But we must not forget that a chemical modification acting in one direction may involve modifications in the constitution and the structure having an opposite effect on a given property. For instance, the decarburization of a martensitic steel may transform it into a coarse-grained ferritic steel, and it will be softened, as when annealing a stainless chromium steel, but a globular pearlitic steel may be transformed into a fine lamellar pearlitic one and thus be hardened, as when annealing steels for ball bearings.

It is also true that the same mechanical operation may provoke varied results, according to its intensity and behavior. Grinding may heat and temper a hardened steel, while a slipping locomotive wheel may harden a rail.

Lastly the sundry effects overlap. Grinding modifies the surface geometrically and provokes thermal effects. Punching scratches the hole and cold works it. Gas cutting modifies the surface geometrically, chemically, and structurally. Pickling of brass may open scratches and, at the same time, selectively dissolve zinc. Metal coating by hot dip may embrittle steel either by the action of the cleaning acid, the dissolution and roughening of the steel, or the formation of a brittle alloy bonded to the surface.

Through this diversity of action, the surface conditions often have a most important influence upon the mechanical behavior of the test pieces and the parts in service.

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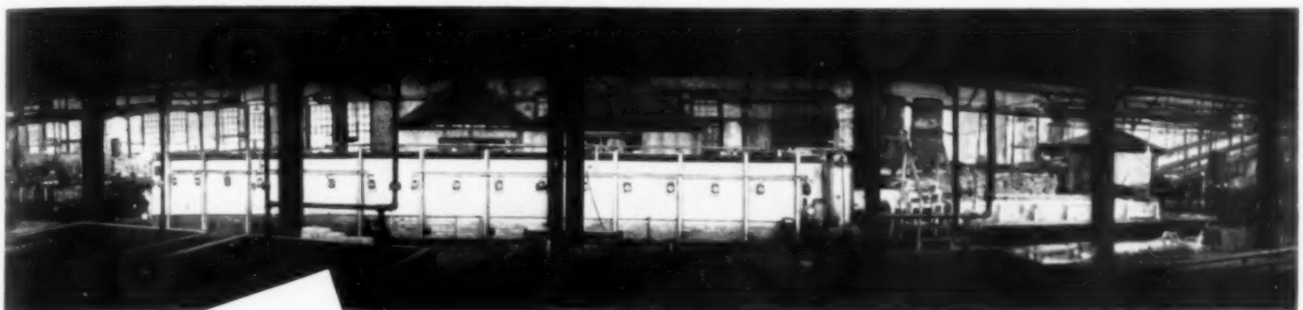

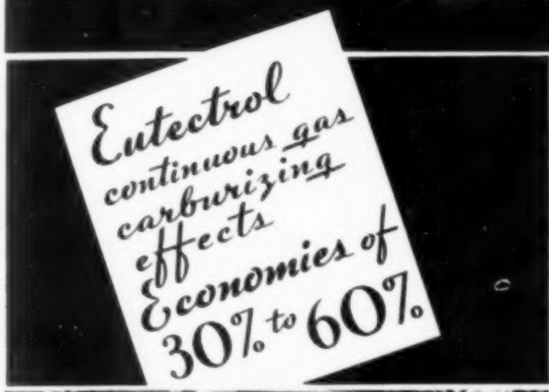

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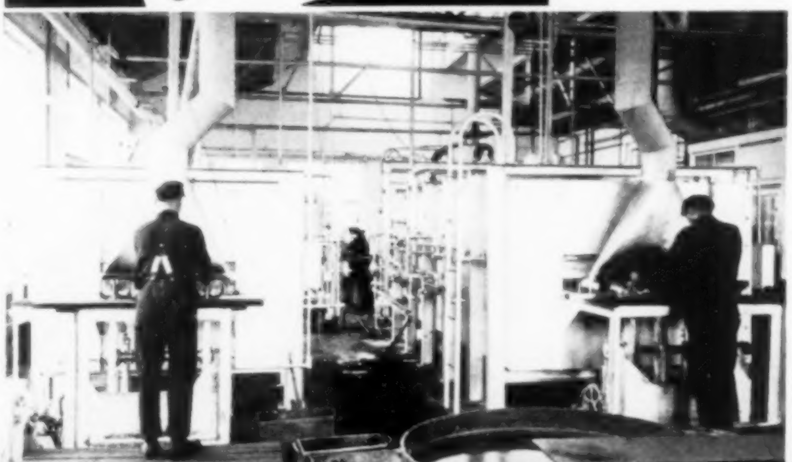

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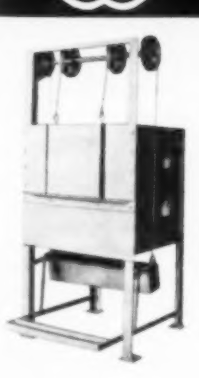

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Ask for these useful pamphlets

Pickling Inhibitors

A pamphlet describing the nature and use of Grasselli Inhibitors is available to all those interested in the pickling of steel. It not only describes the merits of these inhibitors, but it gives a table of suggested inhibitor strengths to be used in the pickling of the various grades of steel. Bulletin Ap—95.

Low Cost Recorder

Inexpensive dependability in measuring and recording temperature is the great asset of the new Leeds & Northrup round chart Micromax indicating recorder which brings the reliability and easy maintenance of the motor-driven null recorder to a new low cost. Bulletin Ap—46.

Closer Heat Control

Anticipatory control action may be obtained with any pyrometer controller by adding the Deoscillator developed by Foxboro Co. A new folder tells how the device prevents over-controlling by augmenting the thermocouple E.M.F. when the temperature is low and opposing it when the temperature is high. Bulletin Ap—21.

Atmosphere Furnaces

A new folder issued by Surface Combustion Corp. gives performance data on their atmosphere furnaces compiled from installations in actual production. Operations described include bright annealing of ferrous and non-ferrous metals, carburizing, nitriding, forging without scale and hardening without scale. Illustrated. Bulletin Ap-51.

Tool Steel Facts

Ludlum Steel Co. is continuing its well-known Blue Sheet Service which consists of reports prepared by its research department, containing accurate data and reference material on tool steel and its properties as disclosed by actual tests. The company will put you on its mailing list for these. Bulletin Ap-94.

Stainless Sheets

A very useful booklet describing the stainless steel sheets and light plates made by American Sheet & Tin Plate Co., gives recommendations for fabrication and a description of finishes and analyses available. Bulletin Ap—96.

Furnace Parts

Various parts for furnaces made from alloys manufactured by Driver-Harris Co. are pictured and described in an interesting publication. Complete performance data and specifications of Nichrome and Chromax heat resisting alloys are given in the booklet. Bulletin N-19.

Scleroscopes

The model D standard recording scleroscope is described and illustrated in a recent publication of Shore Instrument Co. The theory and practice of hardness testing with this portable machine as described in this bulletin reveal a fund of valuable facts. Bulletin S-33.

Turbo Compressors

A series of three bulletins is available from Spencer Turbine Co. describing their Turbo Compressors for oil and gas fired equipment and foundry cupolas. Sizes range from 100 to 2,000 cu. ft., 1 to 300 h. p., 8 oz. to 5 lbs. Bulletin Fe-70.

Extensometer

A simple but rugged extensometer has been developed by Union Carbide & Carbon Research Laboratories. A booklet describes how it works and how to use it for determining either yield point or as a strain gauge to show elongation under specified load. Bulletin Ma-63.

Heat Distribution

The advantages gained by uniform temperature distribution throughout furnace charges are fully described in a publication of Westinghouse Electric & Manufacturing Co. In properly designed electric furnaces, heat can be accurately distributed and controlled, with resultant great savings in cost. Bulletin Ma-497.

High Cr Cast Iron

A pamphlet describing foundry production of cast irons containing from 15 to 30% of chromium has been issued by Electro Metallurgical Co. These cast irons do not grow or scale after repeated heatings and are excellent for high temperature work. Bulletin Ma-16.

Architectural 18-8

A fund of valuable information on the architectural application of Enduro stainless steel is contained in a brochure of Republic Steel Corp. Facts are presented on the fabrication, properties, shapes and finishes available. Well illustrated. Bulletin Ma-217b.

Alloys of Aluminum

Data and tables describing the physical properties and chemical constituents of the several alloys of aluminum are presented in a carefully prepared booklet issued by Aluminum Co. of America. An authoritative discussion of these alloys. Bulletin Fe-54.

Big-End-Up

Gathmann Engineering Co. briefly explains the advantages of steel cast in big-end-up ingots, showing the freedom from pipe, excessive segregation and axial porosity. An 82% ingot-to-bloom yield of sound steel is the usual practice. Bulletin Fe-13.

Tobin Bronze

Engineering data and colored photographs of interesting installations of Tobin Bronze are well combined in a booklet prepared by the American Brass Co. Results of varied tests on rods, shapes and plates make the booklet a useful reference source for this metal. Bulletin Ja-89.

Recuperators

The complete story of recuperators built by Carborundum Co. for industrial furnaces is told in a readable booklet. The range of types available is described and the operating conditions are outlined in a clear manner. Bulletin F-57.

Nickel Steel

International Nickel Co. is publishing an illustrated newspaper called "Nickel Steel Topics" which contains technical, semi-technical and news articles dealing with the production, treatment and uses of nickel alloy steel. Bulletin Ju-45.

Super Blowpipes

The advent of natural gas has made the replacement of many burners imperative. American Gas Furnace Co. describes in an illustrated folder blowpipes, ribbon burners, cross-fires, hand torches, etc., which are suitable for use with natural gas, propane and butane. Bulletin Ja-11.

Titanium in Steel

An elaborate catalogue prepared for technical readers describes the use of ferro-carbon titanium in steel. Titanium Alloy Manufacturing Co. prepared it. The application of titanium in steels for forgings, castings, rails, sheets and plates is thoroughly described. Bulletin J-90.

Micro-Metallograph

Metallurgists will be interested in the description of the Leitz Model MM-2 Micro-Metallograph. This simplified instrument at low cost provides all essential optical and mechanical equipment to meet the requirements of industry. Bulletin Fe-47.

Cast Vanadium Steel

Jerome Strauss and George L. Norris have written a technical booklet for Vanadium Corp. of America describing the properties developed by steel castings containing various percentages of vanadium. The information given is complete and authoritative. Bulletin S-27.

To Prevent Rust

The well known rust preventive, No-Ox-Id, is now available from Dearborn Chemical Co. as a foundation for paint. It is available in the colors red, gray or black. A booklet explains how maximum resistance to corrosion can be obtained. Bulletin Ju-36.

Fatigue Testing

That much discussed topic — fatigue testing — is covered in a publication of Thompson Grinder Co. Interesting data on fatigue of metals and a description of the rotating beam type of fatigue testing machine are presented. Bulletin D-23.

Heating Units

An unique and very useful device for calculating heating units when figuring coiled units, covering wattages from 275 to 1000, has been prepared by Hoskins Mfg. Co. Two slotted cards are clamped back to back through which various data can be read by adjusting a card which slides between. Bulletin D-24.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Corp. A list of the standard industrial type heating elements and a coordinated list of terminal mountings and accessories is included. Bulletin N-25.

Liquid Baths

A competent discussion of liquid baths for heat treating steel at temperatures from 350 to 1800° F. appears in a recent publication of E. F. Houghton & Co. A valuable chapter is devoted to the proper design of furnaces for use with liquid baths which lists 20 general furnace requirements. Bulletin Ja-38.

Refractories

A semi-technical booklet prepared by Norton Co. gives valuable information on the manufacturing processes and the various industrial applications of fused alumina (Alundum), silicon carbide (Crystolon) and fused magnesia refractories products. Bulletin J-88.

X-Rays in Industry

General Electric X-Ray Corp. has available a profusely illustrated brochure entitled "Industrial Application of the X-Ray", which gives the complete story of the field of application of this modern inspection tool. Valuable information is presented. Bulletin Ma-6.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in one of that company's publications. Bulletin D-17.

How to Test Wear

Tests of lubricants or of wear of moving parts may be made accurately with a new machine, made by Timken Roller Bearing Co. A bulletin tells how the machine tests the load carrying capacity of lubricants and measures the friction and wear of materials. Bulletin M-71.

Allegheny 46

This alloy has strength at high temperature and couples corrosion resistance with ease of fabrication. Allegheny Steel Co. has issued a bulletin covering the chemical and physical properties of this low alloy heat and corrosion resisting steel which has many applications in furnace equipment. Bulletin Fe-92.

Cyanides and Salts

Metallurgists will find valuable information in an 80-page booklet published by R & H Chemical Department of E. I. du Pont de Nemours Co. Technical information on the heat treatment of steels with cyanides and salts is presented in a lucid manner. Bulletin D-29.

Heat Treating Data

Brief but accurate summaries of the proper treatments for annealing sheets, wire, welded tanks, malleable castings and forgings are given in a book published by Brown Instrument Co. Normalizing, tempering, hardening and carburizing recommendations as well as many special treatments are included. Bulletin Fe-3.

Welding Mn Steel

Metal and Thermit Corp. offers a new bulletin describing the Murex method of welding manganese steel which utilizes a heavily coated chromium-nickel rod for a strong, ductile joining material and overlays it with wear-resisting manganese steel containing a little nickel. Bulletin Fe-64.

Annealing Forgings

Not only annealing furnaces are described in a recent publication of Electric Furnace Co. Various types of electric and fuel fired furnaces designed for heat treating forgings are described and clearly illustrated. Bulletin Fe-30.

METAL PROGRESS,
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Please have sent to me the following literature as described in the April issue. (Please order by number.)

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Cobalt High Speed

(*Continued from p. 29*) of the tool being hardened. They should be cooled to a temperature under 300 but not below 100° F. Unless equipment is available to keep the tools at a temperature within this range they should be tempered immediately. These steels also may be quenched in molten salt or lead, which is maintained at a temperature of from 1000 to 1100° F. When quenched in a salt or lead bath the tool is allowed to remain in the bath for from 15 to 30 min., then removed and allowed to cool in still air. Tools treated in this manner are subject to the same tempering recommendations as when they are cooled in air or oil.

Temper Twice to Toughen

Tempering — To obtain maximum hardness these steels should be tempered at 1050° F., holding at this temperature from 1 to 3 hr., according to size. A second tempering, at 600 to 650° F. will toughen these steels without materially affecting the initial hardness.

Cobalt tool steels show a tendency to decarburize during the hardening operation in approximately a direct proportion to the cobalt content. Because of this characteristic it is always advisable to grind the working surface of the steel after hardening. It is strongly recommended that the steel be ground after forging and annealing and before hardening to remove any decarburized surface that may have resulted from the forging heat. This precaution will lessen the amount of decarburization.

It is important that the proper grade and speed of wheel be used when grinding a hardened tool, since with too hard or fine a wheel or with too high a speed there is pronounced danger of cracking in grinding. Wet grinding is not generally recommended. In dry grinding care must be taken not to dip tools in water to cool, as this will crack or check the tool.